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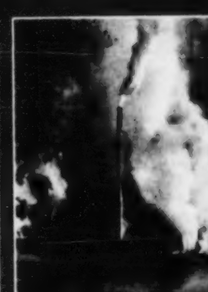
Government of Canada
Five-year Progress Report
Canada-wide Standards for Particulate Matter and Ozone





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January 2007

Message from the Minister

Protecting the air we breathe is a priority for the Government of Canada. That is why the federal government recently committed to an environmental approach that will ensure that future generations enjoy cleaner air across this country.

One important element of any national air quality strategy is to work cooperatively with all levels of government since responsibility for air quality management is shared between the federal government, provinces and territories. One way to coordinate these actions is through the Canada-wide Standards (CWS) for Particulate Matter and Ozone.

This report outlines progress made by the federal government toward meeting the CWS. We are currently 5 years into a 10-year timeline. The report demonstrates that some progress has been made in reducing emissions from the transportation sector and from transboundary sources of air pollution from the United States.

However, these efforts alone will not be enough to achieve the CWS five years from now and to improve air quality across the country. According to data presented in this report, between 2003 and 2005, at least 30% of Canadians lived in communities with fine particulate matter ($PM_{2.5}$) levels above the ambient CWS target, and at least 40% of the population lived in communities with ozone above the ambient CWS target.

Clearly, additional efforts are required if we are going to meet our goals. That is why my government introduced Canada's Clean Air Act and a Notice of Intent to develop and implement regulations and other measures to reduce air emissions. This will help improve air quality and reduce the risks posed by poor air quality to our environment and to the health of Canadians.

By taking strong national action now, and by working cooperatively with all those who have a role to play in air quality management, together we can help clean the air for all Canadians, young and old, regardless of where they live across the country.

John Baird
Minister of the Environment

Executive Summary

Smog is one of the most recognizable air quality problems in Canada. The major components of smog are particulate matter (PM) and ozone. PM, which includes both inhalable particles (or PM_{10}) and fine particles (known as $PM_{2.5}$), is emitted directly into the atmosphere from such sources as cars, trucks, factories, and wood burning, and can also be formed in the air from precursor gases such as nitrogen oxides (NO_X), volatile organic compounds (VOC), sulphur dioxide (SO_2), and ammonia. Ground-level ozone is a secondary pollutant formed in sunlight from precursor gases such as NO_X and VOC, which come from fossil fuel combustion in motor vehicles, power plants and industrial processes as well as some natural sources.

A large body of scientific evidence exists pointing to the significant human health and environmental effects associated with smog. In light of these serious impacts, the Government of Canada published its *Interim Plan 2001 on Particulate Matter and Ozone* (Interim Plan 2001) to share with Canadians the actions it would undertake over the course of the next several years to contribute to the achievement of the Canada-wide Standards for Particulate Matter and Ozone. The Plan was considered interim, recognizing that it constituted a first step toward minimizing the risks related to air quality.

This document represents the first five-year progress report by the Government of Canada. It summarizes activities to the year 2005 taken pursuant to the federal Interim Plan 2001. It also provides an overview of the status of ambient PM and ozone concentrations and emissions trends across the country, as well as an overview of trends in transboundary flows of air pollutants from the United States.

Ambient Levels and Trends

The ambient $PM_{2.5}$ and ozone levels showed that for the 2003 to 2005 period:

- At least 30% of Canadians lived in communities with $PM_{2.5}$ levels above the ambient $PM_{2.5}$ CWS.
- At least 40% of Canadians lived in communities with ozone levels above the ambient ozone CWS.
- Locations with PM or ozone levels above the Standards were found primarily in Ontario and Quebec, with few communities in British Columbia and Atlantic Canada. Many communities across Canada were approaching the Standards (within 10%).

Regarding trends, ambient levels of the major ozone precursors (NO_X and VOC) decreased over the 15-year period 1991 to 2005. However, ozone levels in the form of the ozone CWS (which considers the 4th highest levels) remained largely unchanged. The decrease in ambient nitric oxide (NO) levels at many urban locations, with a resulting decrease in ozone scavenging, is the most apparent reason why the 4th highest ozone levels remained unchanged. Modelling and observational analysis continue to support the view that reductions in both VOC and NO_X will benefit urban areas while NO_X reductions may be more effective in lowering widespread ozone concentrations, benefiting rural areas.

Smog Management Efforts

The Interim Plan 2001 outlined a series of short- and longer-term measures to help achieve the CWS. These measures reflected a combination of approaches, including regulations, voluntary programs and policies, and investments in science, monitoring, and technology innovation.

The **transportation sector** is the largest contributor to the total national anthropogenic emissions of NO_X and VOC in Canada, and is also a source of SO_2. The 2001 Federal Agenda on Cleaner Vehicles, Engines and Fuels led to the introduction of a series of regulations and measures to reduce emissions from on-road vehicles, off-road engines and fuels, many of which align with actions initiated in the United States. Initial work has also been conducted to reduce emissions from the marine, rail and aviation sectors.

Consumer and commercial products are major sources of both VOC (from solvents such as household and industrial cleaners, and degreasers), and direct $PM_{2.5}$ emissions (from residential wood stoves and fireplaces). In recognition of the significance of these sources, the federal government:

- Published a Notice of Intent (NOI) in March 2004 of a Federal Agenda on the Reduction of Emissions of Volatile Organic Compounds from Consumer and Commercial Products. This agenda will help guide the development and implementation of VOC reduction measures, which may align with similar efforts in the U.S., given the widely shared market in this sector.
- Worked with other jurisdictions to develop a model municipal bylaw to reduce emissions from residential wood-burning appliances.

The combined emissions from ***industrial sectors*** and ***electricity generation*** contributed the most to the national aggregated emissions of four smog-producing pollutants in 2000. Federal efforts in this area have emphasized coordinated actions with other jurisdictions.

- Through federally required base metal smelter Pollution Prevention Plans, it is expected that the sector will reduce annual sulphur dioxide emissions by over 600,000 tonnes (about 70%) and will reduce annual particulate matter emissions containing metals by over 3,000 tonnes (about 50%) by 2015 from 1998 levels.
- The Government of Canada *New Source Emission Guidelines for Thermal Electricity Generation* (2003) contains limits for emissions of SO_2, NO_X and PM from new power plants, with the intent of ensuring that new plants and replaced generating units are built clean.

Other **supportive federal actions** include efforts to green federal government operations; support of partnership programs; innovation and development of new technologies goals (Sustainable Development Technology Canada and Natural Resources Canada); and economic measures to promote advances in the renewable energy field.

While there are a number of locations across Canada in which ambient levels are currently below the $PM_{2.5}$ and ozone CWS, actions are required to ensure that these levels do not rise. Substantial evidence exists of the harmful effects of these pollutants throughout the range of concentrations to which Canadians are exposed and further buttresses the need to reduce these levels over time. Federal efforts contributing to the goals of ***continuous improvement*** and ***keeping clean areas clean*** include all of the actions outlined above, and specifically regulations for the transportation sector as they apply to all regions of Canada.

The Interim Plan 2001 also underscored the importance of **international cooperation for clean air**, particularly with the United States, given that in some regions of eastern Canada, between 30% and 90% of smog comes from the U.S. The Ozone Annex under the ***Canada–U.S. Air Quality Agreement*** has proven to be an effective vehicle for engaging cooperation in air management.

- Significant strides have been made by the U.S. in reducing transboundary flows of air pollutants over the last five years. It is anticipated that implementation of U.S. commitments will reduce annual NO_X emissions in the U.S. Pollutant Emissions Management Area (which includes a number of States close to the eastern Canadian border) by 51% and annual VOC emissions by 49% from 1990 levels by 2010. Canada is expected to benefit from these major reductions.

The Government of Canada plays a key role in **researching, measuring and monitoring air quality** issues and their impact on human health and the environment across the country.

- Federal investments have significantly expanded the number of stations monitoring PM and ozone. At this time, all communities with a population greater than 100,000 can now effectively report on achievement of the CWS.
- The National Pollutant Release Inventory has expanded the list of substances reported by facilities to include NO_X, VOC, PM, sulphur oxides, carbon monoxide, ammonia and individual or specific groups of VOC.
- Health Canada has conducted or facilitated several major research projects on the health effects of air pollution, and is developing methods to track the effects of air pollution and assess the impacts of actions taken to reduce air pollution.
- Environment Canada has played a significant role in conducting field studies and other research on different aspects of air pollution.

In addition to informing the work of decision makers, much of this information has supported the development of public outreach tools, such as Air Quality Forecasts. These tools can help Canadians understand how to better manage the risks to their health posed by air pollution, as well as the actions they can take to reduce their contribution to air emissions.

Emissions Trends and Projections

According to data compiled in collaboration with provincial, territorial and regional agencies, emissions of smog-producing pollutants decreased both nationally and regionally between 1990 and 2000. Projections out to 2015 indicate that:

- National emissions of SO_2 and NO_X are projected to continue decreasing, although at a much slower pace than in the previous years.
- National emissions of VOC are projected to increase, while emissions of primary $PM_{2.5}$ are projected to stay relatively stable with a projected 6% increase.
- Regional emissions of SO_2 and VOC for the region west of the Ontario–Manitoba border (including the three territories) are projected to increase, while emissions of primary $PM_{2.5}$ and NO_X are projected to stay relatively stable, with projected increases of about 5%. The increase in emissions is largely as a result of accelerated growth in sectors such as upstream oil and gas (includes oil sands). Increases in these sectors should offset reductions from the transportation sector.
- Regional emissions of SO_2 and NO_X for regions east of the Ontario–Manitoba border are projected to decrease, while emissions of primary $PM_{2.5}$ and VOC are projected to stay relatively stable with projected increases of 6% for $PM_{2.5}$ and decreases of 6% for VOC.

In Conclusion...

Progress has been made in a number of areas pursuant to the Interim Plan 2001, including major strides related to reducing emissions from the transportation sector, transboundary sources of air pollution and establishing strong air quality monitoring networks across the country. These actions have strengthened smog reduction efforts and made tangible contributions to clearing the air for Canadians, as noted, for example, in the reductions in the ambient levels of NO_X and VOC.

At the same time, further work will be required in both Canada and the U.S. to improve air quality and help all jurisdictions achieve the CWS by 2010. In particular, accelerated efforts are required to determine the sources that are contributing to elevated levels of these pollutants and to implement emission reduction strategies in key sectors. These and other measures will be considered by the Government of Canada as part of evolving efforts toward managing emissions of both smog-producing pollutants and greenhouse gases.

Table of Contents

Table of Contents *(continued)*

List of Figures

List of Acronyms, Abbreviations and Symbols

≤	Less than or equal to
≥	Greater than or equal to
AAFC	Agriculture and Agri-Food Canada
ATAC	Air Transport Association of Canada
AQA	Air Quality Agreement
AQRD	Air Quality Research Division
AQS Database	Air Quality System Database (U.S.)
AURAMS	A Unified Regional Air Quality Modelling System
BAM	Beta Attenuation Monitor
BAQS	Border Air Quality Strategy
CA	Census Agglomeration
CAC	Criteria Air Contaminants
CAEP	Committee on Aviation Environmental Protection
CAIR	Clean Air Interstate Rule (U.S.)
CAOL	Clean Air Online
CAPMoN	Canadian Air and Precipitation Monitoring Network
CCME	Canadian Council of Ministers of the Environment
CEPA	*Canadian Environmental Protection Act, 1999*
CI	Continuous Improvement
CMA	Census Metropolitan Area
CRUISER	Canadian Regional and Urban Investigation System for Environmental Research
CSD	Census Subdivision
CWS	Canada-wide Standards for Particulate Matter and Ozone
EC	Elemental carbon
EPA	Environmental Protection Agency (U.S.)
EPWG	Emissions and Projections Working Group
ESDI	Environment and Sustainable Development Indicators
FAA	Federal Aviation Administration (U.S.)
FHIO	Federal House in Order
GDAD	*Guidance Document on Achievement Determination*
GHG	Greenhouse gases
GMF	Green Municipal Fund
ICAO	International Civil Aviation Organization
ICARTT	International Consortium for Atmospheric Research on Transport and Transformation
IMPROVE	Interagency Monitoring of Protected Visual Environments (U.S.)
JIA	Joint Initial Action
KCAC	Keeping Clean Areas Clean
km	Kilometre
kt	Kilotonne
kW	Kilowatt
LU station	Large urban station
MERAF	Multi-pollutant Emission Reduction Analysis Foundation
MERS	Multi-pollutant Emission Reduction Strategies
mg/kg	Milligram per kilogram

List of Acronyms, Abbreviations and Symbols *(continued)*

Mt	Megatonne
$\mu g/m^3$	Microgram per cubic metre
μm	Micrometre
MOU	Memorandum of Understanding
MW	Megawatt
NAAQS	National Ambient Air Quality Standard (U.S.)
NAESI	National Agri-Environmental Standards Initiative
NAPS	National Air Pollution Surveillance
NASA	National Aeronautics and Space Administration
NH_3	Ammonia
NO	Nitric oxide
NO_2	Nitrogen dioxide
NO_x	Nitrogen oxides
NOI	Notice of Intent
NPRI	National Pollutant Release Inventory
NRCan	Natural Resources Canada
NRTEE	National Round Table on the Environment and the Economy
NU station	Non-urban station
O_2	Oxygen
O_3	Ozone
OC	Organic carbon
OGGO	Office of Greening Government Operations
PARTNER	Partnership on Air Transportation Noise and Emissions Reduction
PEMA	Pollutant Emission Management Area
ppb	Parts per billion
ppbC	Parts per billion per carbon
ppm	Parts per million
PM	Particulate matter
$PM_{2.5}$	Fine particulate matter; particles with diameter $\leq 2.5\ \mu m$
PM_{10}	Inhalable particulate matter; particles with diameter $\leq 10\ \mu m$
RAC	Railway Association of Canada
RASCAL	Rapid Acquisition Scanning Aerosol Lidar
RSA	Reporting Sub-area
SDGO	Sustainable Development in Government Operations
SIP	State Implementation Plan (U.S.)
SO_2	Sulphur dioxide
SU station	Small urban station
TEOM®	Tapered Element Oscillating Microbalance
TSRI	Toxic Substances Research Initiative
UNECE	United Nations Economic Commission for Europe
VOC	Volatile organic compounds
WHO	World Health Organization

1. INTRODUCTION

In June 2000, the Canadian Council of Ministers of the Environment (CCME) (except Quebec[1]) endorsed the Canada-wide Standards (CWS) for Particulate Matter and Ozone, which comprise ambient Standards to be achieved by 2010. The CWS were developed in response to the detrimental effects associated with particulate matter (PM) and ozone, while recognizing that achieving the Standards is a first step toward the long-term goal of minimizing the risk posed by these two pollutants to human health and the environment.

The CWS agreement contains a number of provisions, including ambient Standards for PM and ozone that federal, provincial and territorial jurisdictions committed to achieve by 2010; guidance for continuous improvement (CI) and keeping clean areas clean (KCAC); a requirement for jurisdictions to develop implementation plans; a commitment from the federal government to aggressively pursue further reductions in the transboundary flow into Canada of PM and ozone and their precursor pollutants; establishment and maintenance of monitoring networks; reviews of the CWS in 2005 and 2010; and a commitment for jurisdictions to report to ministers and the public at regular intervals.

Each jurisdiction committed to actions aimed at meeting the ambient Standards and to reporting on achievement once the target date is reached in 2010. Reporting on achievement includes comprehensive reports on all provisions of the CWS which are to be produced every five years (the *Five-year Reports*) beginning in 2006, and annual reports on achievement and maintenance of the Standards beginning in 2011. The first Five-year Report, covering the period to 2005, is an interim report on progress toward meeting the CWS.

The Five-year Reports are meant to be comprehensive assessments of progress on all provisions of the CWS. As agreed to under the CWS, information in these jurisdictional reports should include:

- comprehensive descriptions of smog management efforts and progress in implementing measures in implementation plans;
- actions to ensure continuous improvement and keeping clean areas clean;
- cooperation in monitoring and science;
- information on PM and ozone precursor emissions and trends;
- assessment of ambient levels and trends in communities within each jurisdiction, as well as identification of communities where ambient levels are exceeding or approaching the CWS levels; and
- for the federal government, an assessment of trends in emissions and ambient levels for the United States in border regions affecting ambient PM and ozone levels in Canada, and an assessment of both the effectiveness of U.S. control programs in reducing those emissions, and of Canadian efforts to secure such reductions.

This document represents the Government of Canada's Five-year Progress Report for the period 2000 to 2005.

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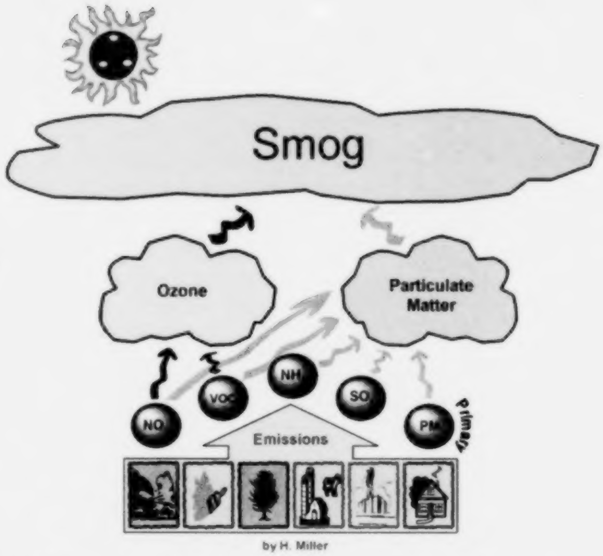
[1] Although Quebec has not endorsed the CWS, it has committed to act in coherence with other jurisdictions in relation to the CWS.

2. SMOG AND ITS EFFECTS

Smog is one of the most recognizable air quality problems in Canada. It refers to a noxious mixture of air pollutants which often gives the air a *hazy* appearance. The major components of smog in Canada are ozone and particulate matter (PM) in the summer, and PM in winter. These pollutants have been linked to a number of adverse effects on human health and the environment.



PM refers to microscopic solid and liquid particles that remain suspended in the air. Particles are what make the air look hazy on days with smog since they impair visibility. Ozone is a colourless gas that forms in the air. Smog-producing pollutants include direct PM emissions and the gases sulphur dioxide (SO_2), nitrogen oxides (NO_x), volatile organic compounds (VOC) and ammonia (NH_3).

In summer, large-scale smog episodes are typically associated with slow-moving high pressure systems, which bring with them very high temperatures, light winds and at times stagnant conditions, both of which allow the build-up of locally emitted pollutants. In the eastern part of Canada, southerly winds typically accompany these episodes, bringing with them pollutants from the United States. In winter, large-scale smog episodes are typically associated with high levels of PM, often brought about by a build-up of locally emitted pollutants under stagnant air.

Smog is a concern in many urban centres across Canada, and it can also be a concern in rural undeveloped areas, since emissions of smog-producing pollutants can be transported by the prevailing airflows over large distances and affect air quality in areas hundreds to thousands of kilometres away from their sources.

The rest of this section provides more information on the nature of PM and ozone, and on their health and environmental effects.

2.1 Nature of Particulate Matter

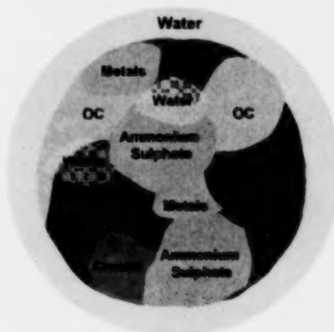
Particulate matter (PM) represents the collection of very tiny liquid and solid particles that are suspended in the air. Individual particles are typically composed of a very complex mixture of chemical species, and some particles are also carriers of known toxic substances, such as polycyclic aromatic hydrocarbons, some of which are known carcinogens. Many particles have a solid core surrounded by a liquid layer.

> **Understanding the Composition of Particles**
>
> Knowing the composition of particles is important as it can be used for the identification of the sources contributing to the ambient PM. Health research is also increasingly pointing to the need to identify the PM components that may be responsible for the health effects.

Particles come in a variety of sizes. Two broadly monitored size fractions are particles with diameter less than or equal to 10 micrometres (μm), known as *inhalable particles* (or PM_{10}), and those with diameter less than or equal to 2.5 μm, known as *fine particles* ($PM_{2.5}$).

PM is emitted directly to the air (*primary* PM), and it also forms in the air (*secondary PM*) from precursor gases such SO_2, NO_X, VOC and NH_3.
Sources of primary PM include soot (*elemental carbon*, or EC) emitted directly from combustion of fossil fuels; metals such as iron, lead, mercury and cadmium; elements of soil and road dust; bio-aerosols (i.e. particles containing or composed of living micro-organisms such as fungal spores and mould); and salt (e.g. road salt and oceanic sea-salt).

Schematic of a particle



by H. Miller

Secondary PM includes: *ammonium sulphate* (produced in the air from emissions of SO_2 and NH_3); *ammonium nitrate* (produced in the air from emissions of NO_x and NH_3); and numerous carbon-containing substances (known as *organic carbon*, or *OC*), which may be emitted directly or formed in the air from emissions of VOC.

PM is a very complex pollutant, not only because particles typically consist of a mixture of substances, but also because some of the substances that make up the particles are semi-volatile. Semi-volatile substances can exist in the air both as particles and vapours (i.e. gases). The mass of semi-volatile PM (e.g. ammonium nitrate and some organic compounds) is not static but can instead change frequently as the substances respond to the changing meteorological, physical and chemical conditions that they encounter while moving through the air.

Ambient levels of particles can be elevated year-round, and in urban areas the levels are typically higher in the mornings and evenings, reflecting traffic patterns. Particles can travel very large distances and affect areas thousands of kilometres away from the sources of the emissions.

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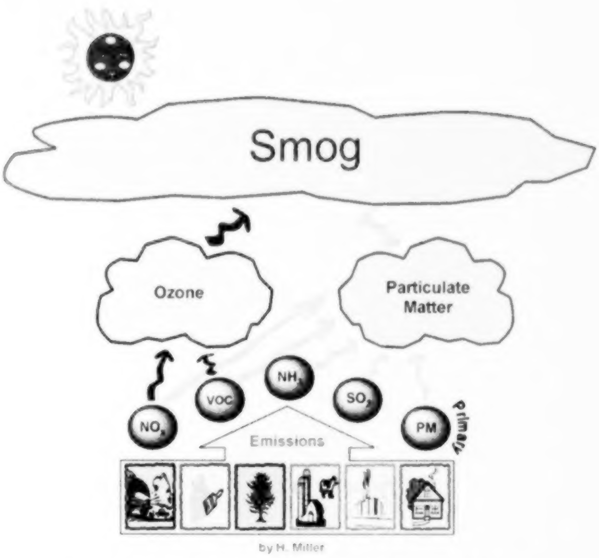

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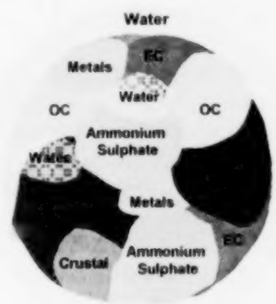

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2.2 Nature of Ozone

Ozone (O_3) is a different form of the familiar oxygen (O_2). Ozone levels broadly increase with height to reach a maximum at approximately 25 km above the Earth's surface in what is known as the *ozone layer,* located in the layer of the atmosphere known as the *stratosphere*. Because all ozone absorbs the harmful ultraviolet rays emitted by the sun, stratospheric ozone is essential. At ground level, however, ozone is considered a pollutant because it also causes adverse health and environmental effects.

Ozone *forms* in the air during daylight hours. In the layer of the atmosphere which is in contact with the Earth's surface (i.e. the *troposphere*), it forms from complex reactions involving precursor pollutants, with the most important being NO_x and VOC.

Ambient ozone levels vary considerably on an hourly, daily and monthly basis, depending on the prevailing meteorological conditions and where the air comes from. Stratospheric ozone can also at times be brought down to the surface and contribute to the ambient ozone levels.

In many parts of Canada, the short-term (1- to 8-hour averages) peak ozone levels produced from NO_x and VOC are typically the highest in the summer months because ozone formation is favoured by strong sunlight and high air temperatures. *Monthly average* levels, however, are typically the highest in spring months. Like $PM_{2.5}$, ozone can be transported by the winds over large distances and affect areas hundreds to thousands of kilometres away from the sources of the precursors.

Ground-level Ozone

Ground-level ozone forms in the air following the dissociation of nitrogen dioxide (NO_2). As NO_2 absorbs sunlight, it splits into nitric oxide (NO) and an unstable form of oxygen (O), which immediately merges with the familiar oxygen (O_2) to form ozone (O_3).

NO_2 and NO (known as nitrogen oxides, or NO_x) are emitted by the same sources. However, most of the ambient NO_2 is actually formed in the air from the conversion of the emitted NO.

The conversion of NO to NO_2 occurs when NO reacts with other substances, such as ozone. In addition to the generation of NO_2, the reaction of ozone and NO is also a process (known as ***ozone scavenging***) through which ozone is removed from the air, since during the reaction ozone converts to oxygen (O_2).

NO, NO_2 and ozone are interrelated. If the air contained only these three substances, a cycle of ozone formation and scavenging would form, leading to an equilibrium between the three substances, and resulting in ozone levels which would be relatively low.

The presence of VOC, however, disrupts this equilibrium since VOC provide a pathway for NO to convert to NO_2 without scavenging ozone. With NO_2 now also being formed from reactions involving NO and VOC, the formed ozone can accumulate in the air, thereby leading to significantly higher ozone levels than would occur from the NO_x-ozone equilibrium alone.

Effects of Reductions in Ambient NO

Reductions in NO_x emissions in urban areas that cause a decrease in the local ambient NO levels can cause an increase in local ozone levels because of the resulting decrease in the amount of ozone scavenged. This effect may be more pronounced in urban areas which are affected by ozone that is transported into the area. Downwind from the urban area, however, the reductions in emissions could lead to less ozone formation and contribute to decreasing ozone levels.

2.3 Health and Environmental Effects

Breathing air with smog has adverse and varied consequences for human health, with the cardio-respiratory system being the main target of concern. Wherever its location and whether visible or not, smog is hazardous to human health.

Ground-level ozone has been linked with a broad spectrum of human health effects. Because of its reactivity, ozone can injure biological tissues and cells. Exposure to ozone has been associated with mortality, hospital admissions, emergency department visits and other adverse health effects.

Exposure to airborne particles at the levels typically found in North American urban areas is associated with a variety of adverse effects. Particles can irritate the eyes, nose, and throat and cause coughing, breathing difficulties, reductions in lung functions, and an increase in the use of asthma medication. Exposure to particles is also associated with an increase in the number of emergency department visits, an increase in hospitalizations of people with cardiac and respiratory disease, and in premature mortality.

There is clear evidence of the harmful effects of these pollutants throughout the range of concentrations to which Canadians are exposed. This means that any reduction in the ambient levels of these pollutants provides a reduction in population health risk.

Negative effects on the environment associated with these pollutants include visibility impairment and ecosystem acidification (for PM), and crop damage and greater vulnerability to diseases in some tree species (for ozone).

All of these adverse effects lead to significant economic losses and reductions in productivity as a result of absenteeism from school and work, increased medical care and hospitalizations, and reduced product quality and yields.

Summary of Section 2

PM and ground-level ozone are the two principal components that comprise smog. These pollutants pose serious health and environmental concerns. Ozone is a secondary pollutant because it is not emitted directly to the atmosphere but rather is formed in air from complex reactions between the precursor gases NO_X and VOC in the presence of sunlight. PM has both a primary and a secondary component. Primary PM is released directly to the atmosphere from combustion or mechanical processes. Secondary PM is formed in the atmosphere from the precursor gases SO_2, NO_X, VOC and NH_3. PM and ozone can be transported by prevailing air flows over long distances, making them not only a concern for urban centres across Canada but also for many smaller communities and rural areas.

Breathing air with smog has adverse and varied consequences for human health, with the cardio-respiratory system being the main target of concern. There is clear evidence of the harmful effects of $PM_{2.5}$ and ozone throughout the range of concentrations to which Canadians are exposed.

3. THE AMBIENT STANDARDS AND REPORTING ON PROGRESS

The CWS contain a number of provisions. This section presents information on the provisions relating to the PM and ozone ambient Standards, and the requirements for reporting on achievement of the Standards.

3.1 Standards to be Achieved by 2010

Under the CWS, jurisdictions defined ambient Standards for fine particulate matter ($PM_{2.5}$) and ozone to be achieved by 2010. The Standards are recognized as an important first step toward the long-term goal of minimizing the risks that PM and ozone pose to human health and the environment. The Standards and their statistical forms are as follows:

$PM_{2.5}$ CWS – 30 $\mu g/m^3$ as a 24-hour average

The ***form of the Standard*** is the ***3-year average*** of the annual 98th percentile 24-hour average $PM_{2.5}$ levels.

Ozone CWS – 65 ppb as an 8-hour average

The ***form of the Standard*** is the ***3-year average*** of the annual 4th highest of the daily maximum 8-hour average ozone levels.

At the time the CWS were endorsed, these Standards represented a balance between a desire to achieve the best health and environmental protection possible in the near term, and the feasibility and costs of reducing the smog-producing emissions.

The $PM_{2.5}$ and ozone Standards can be viewed as consisting of two parts. The first part expresses the numerical values themselves, that is 30 $\mu g/m^3$ for $PM_{2.5}$ and 65 ppb for ozone, and the second part is the ***form*** of the Standards. The form of the Standards states how the measured $PM_{2.5}$ and ozone levels are to be expressed for evaluating whether the Standards are being achieved or not. These forms are the specified 3-year averages.

3.2 Reporting Requirements

To guide jurisdictions in reporting on the achievement of the ambient Standards in 2010, the CCME has developed specific procedures and methodologies, which are outlined in the *Guidance Document on Achievement Determination*[2] (GDAD). The GDAD is intended as a reference tool for jurisdictions and the public, and for ensuring consistency and comparability of data. This section provides an outline of the basic elements for reporting on achievement of the Standards.

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[2] http://www.ccme.ca/assets/pdf/gdad_eng_oct4.pdf

Under the CWS, a community approach to reporting is used, based on communities identified by the Census Metropolitan Areas (CMAs), Census Agglomerations (CAs) and Census Subdivisions (CSDs) defined by Statistics Canada. As a basic requirement, jurisdictions will report on achievement for communities with a population over 100,000. They may also report on smaller communities based on considerations such as regional population density, proximity to sources and local air quality. For large metropolitan areas, jurisdictions may choose to subdivide into reporting sub-areas (RSAs) to better represent variation in $PM_{2.5}$ and ozone levels across the community or to delineate specific urban centres within the larger metropolitan area.

Jurisdictions will report on CWS achievement for communities with a population over 100,000 and may also report on smaller communities as warranted.

Once jurisdictions have defined their reporting communities, monitoring stations are designated for the purpose of evaluating achievement of the Standards. One or more CWS monitoring stations can be designated within the reporting community or RSA, however, the GDAD specifies different reporting procedures depending on the number of CWS monitoring stations used. To guide monitoring program design and operations, and to ensure the coordination of monitoring data, jurisdictions have cooperated in the establishment of a *Monitoring Protocol*[3].

3.3 Accounting for Transboundary Flow and High Background Levels

The CWS also recognizes and takes into account two special circumstances that can affect the ability of a community to achieve a Standard. These are contributions to local ambient PM and ozone levels from the transboundary transport of air pollutants from other provinces and/or the United States, or from high background levels[4] of PM and ozone. In these circumstances, the jurisdiction will demonstrate that: (1) these influences were primarily responsible for the community not being able to achieve a Standard; (2) it has implemented best efforts to reduce emissions within the jurisdiction.

[3] In draft at time of printing.

[4] For the CWS, background is defined as the ambient levels of particulate matter and ozone resulting from anthropogenic and natural emissions outside North America, and natural sources within North America.

Summary of Section 3

The Canada-wide Standards for Particulate Matter and Ozone were endorsed by the CCME (except Quebec) in June 2000. These Standards are set at 30 $\mu g/m^3$ for $PM_{2.5}$ (24-hour average) and 65 ppb for ozone (8-hour average). The CWS also specifies that these Standards are to be achieved by 2010.

To ensure consistent and comparable reporting on achievement of the CWS, jurisdictions have cooperated on the establishment of a *Guidance Document on Achievement Determination*. This document describes the specific procedures and methodologies for reporting on achievement of the Standards, including provisions relating to accounting for transboundary flow and influence from background levels and natural events.

4. AMBIENT LEVELS AND TRENDS

This section presents information on ambient $PM_{2.5}$ and ozone levels and trends in Canada, and also for border regions of the United States and Canada. Unless otherwise noted, all ambient $PM_{2.5}$ and ozone levels in this section are expressed in the form of their respective Standards.

Canadian Ambient Data Source

The Canadian ambient data in this report were collected through the National Air Pollution Surveillance (NAPS) Network, a joint federal, provincial, territorial and municipal program. Data from both NAPS-designated sites and other sites operated or supervised by provincial, territorial and municipal jurisdictions are also included. Data from ozone monitors operated by the Canadian Air and Precipitation Monitoring Network (CAPMoN) are also used. CAPMoN is operated by Environment Canada.

As mentioned in Section 1, communities where levels are "approaching" the Standards are to be identified in the Five-year Reports. For the purposes of this report, approaching the Standards is considered as being within 10% of the Standards. Within 10% of the Standards is therefore the range 27 to 30 μg/m^3 for $PM_{2.5}$, and 59 to 65 ppb for ozone. These ranges are indicated in yellow in the appropriate figures presented in the sections below.

As discussed in Section 3.3, the CWS contain provisions for demonstrating the influence of transboundary flow and high background levels for communities whose continued exceedance of the CWS ambient levels is primarily due to one or both of these two circumstances. As the CWS are to be achieved in 2010, this analysis would be included with reporting beginning in 2011. The ambient data presented in this report are the levels as measured by the monitors.

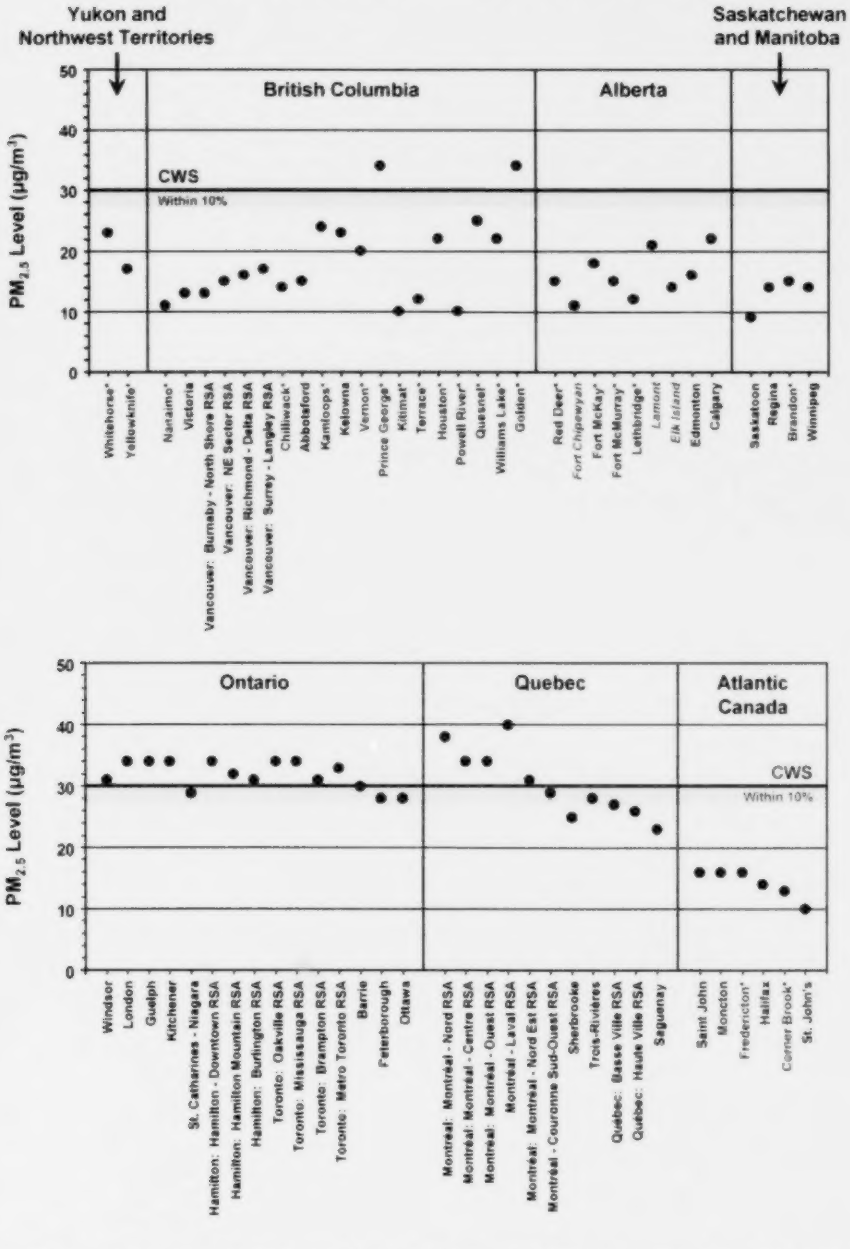
4.1 $PM_{2.5}$ Levels

Figure 1 shows the $PM_{2.5}$ levels in the form of the CWS for Canadian communities and reporting sub-areas (RSAs) for the period 2003-2005. Figure 2 shows the CMA, CA, CSD and RSA boundaries for these communities and areas along with their associated levels in the form of the Standard. The levels in these figures are as reported by provincial and territorial jurisdictions in accordance with the procedures detailed in the GDAD.

For the period 2003 to 2005, at least 30% of the Canadian population (approximately 10 million) lived in communities with levels above the CWS. Most of these were located in Ontario and Quebec. Outside these two provinces, only two communities in the interior of British Columbia had levels above the Standard. Communities within 10% of the Standard were also primarily located in Ontario and Quebec.

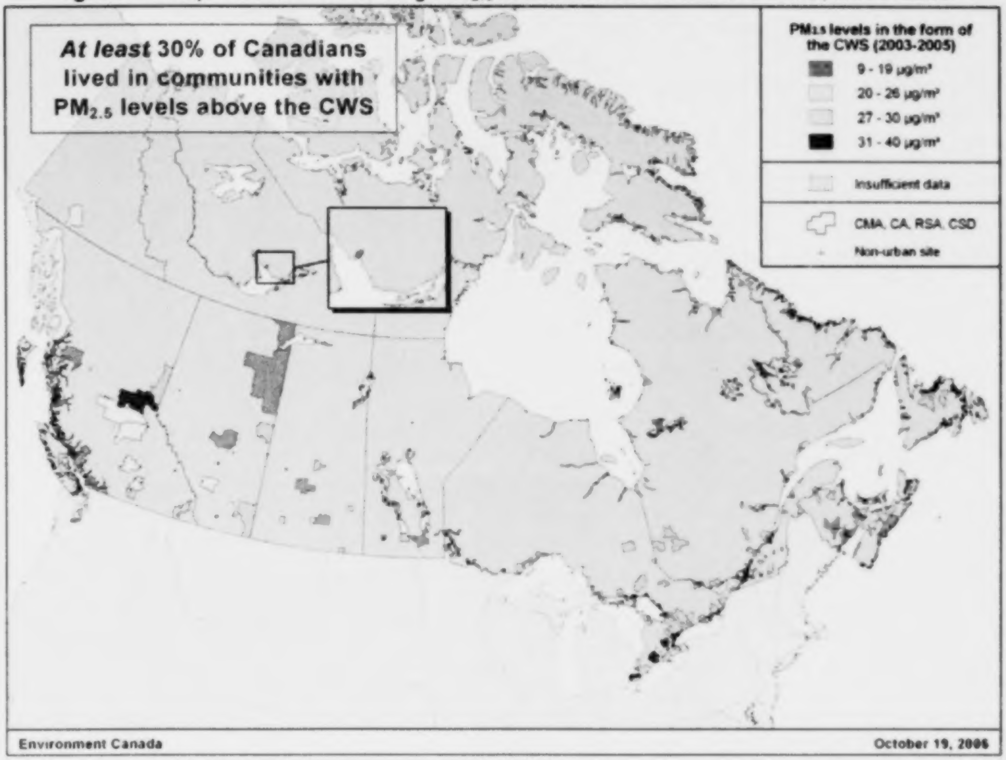
In the western part of Canada, $PM_{2.5}$ levels varied (Figure 1) from 17 to 23 μg/m^3 in Yukon and the Northwest Territories, 10 to 34 μg/m^3 in British Columbia, 11 to 22 μg/m^3 in Alberta, and 9 to 15 μg/m^3 in Saskatchewan and Manitoba. In the eastern part of Canada, levels varied from 28 to 34 μg/m^3 in Ontario, 23 to 40 μg/m^3 in Quebec, and 10 to 16 μg/m^3 in Atlantic Canada.

Figure 1: $PM_{2.5}$ levels in the form of the CWS, 2003-2005



Notes: Shown are the values of the 3-year average of the annual 98th percentiles of the daily 24-hour $PM_{2.5}$ based on the procedures in GDAD. Yellow band represents levels within 10% of the CWS. Values for Kitchener and Guelph are based on two years of data. The $PM_{2.5}$ levels shown are from continuous monitors, consisting of the TEOM® (the majority) and BAM monitors. In blue with * are communities with populations of 100,000 or less that jurisdictions elected to report on. In *green italic* are non-urban monitoring stations. Data provided by provincial and territorial jurisdictions, and generated from measurements collected through NAPS. Data are preliminary and subject to change following further data quality assurance reviews.

Figure 2: Map of Canada showing $PM_{2.5}$ levels in the form of the CWS, 2003-2005



Notes: Shown are the values of the 3-year average of the annual 98th percentile of the daily 24-hour average $PM_{2.5}$ based on the procedures in the GDAD. Values for Kitchener and Guelph are based on two years of data. Blue-hatched areas have insufficient data. Data provided by provincial and territorial jurisdictions, and generated from measurements collected through NAPS. Data are preliminary and subject to change following further data quality assurance reviews.

4.2 Ozone Levels

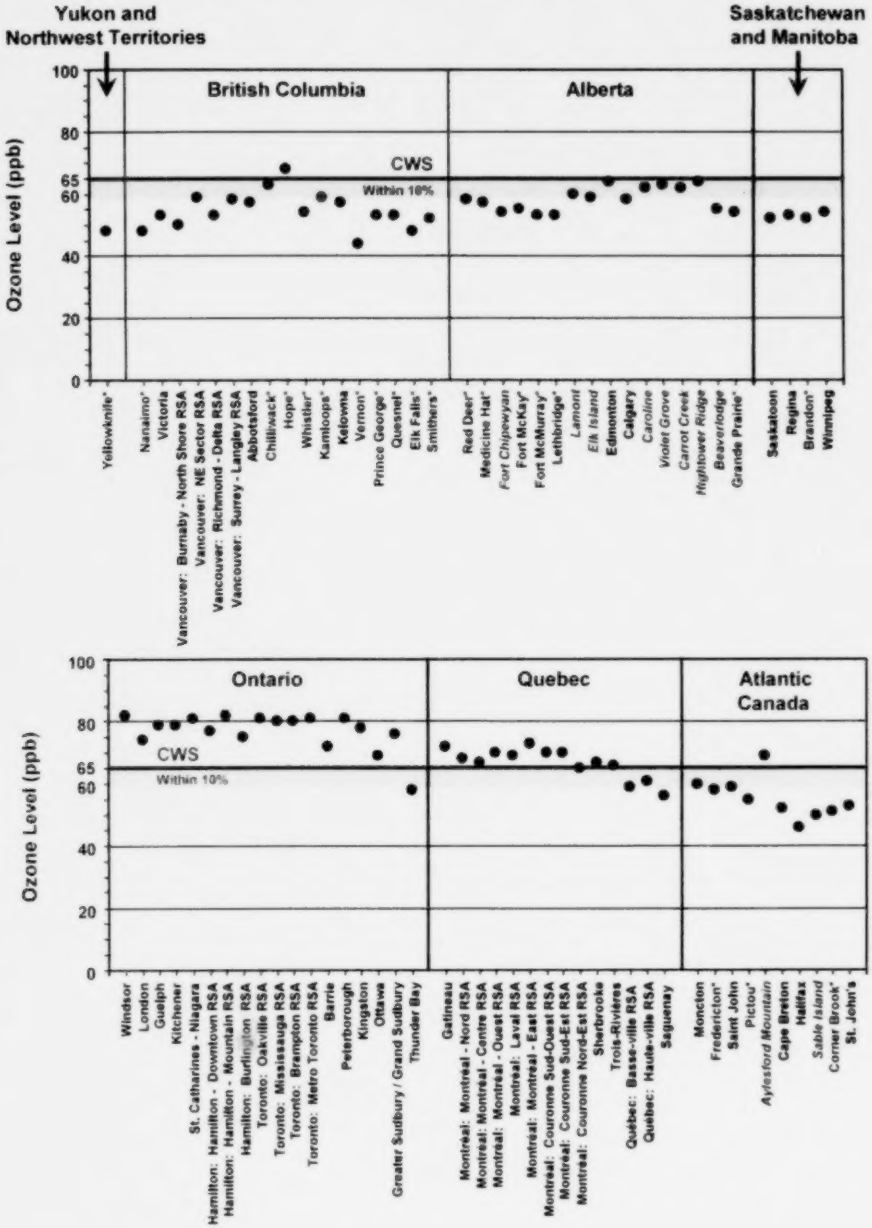
Figure 3 shows ozone levels in the form of the CWS for Canadian communities and reporting sub-areas (RSAs) for the period 2003-2005. Figure 4 shows the CMA, CA, CSD and RSA boundaries for these communities and areas along with their associated levels in comparison to the Standard. The levels in these figures are as reported by provincial and territorial jurisdictions in accordance with the procedures detailed in the GDAD.

For the period 2003 to 2005, at least 40% of the Canadian population (approximately 13 million) lived in communities with levels above the CWS. Most of these were located in Ontario and Quebec. Outside these two provinces, only one community in British Columbia and one non-urban area in Atlantic Canada had levels above the CWS. With the exception of Saskatchewan, Manitoba and the territories, all other regions had at least one location with levels within 10% of the CWS (yellow range).

In the western part of Canada, ozone levels varied (Figure 3) from 44 to 68 ppb in British Columbia, 53 to 64 ppb in Alberta, 52 to 54 ppb in Saskatchewan and Manitoba, and at the single monitored community in the Northwest Territories, the level was 48 ppb. In the eastern part of Canada, levels varied from 58 to 82 ppb in Ontario, 56 to 73 ppb in Quebec, and 46 to 69 ppb in Atlantic Canada.

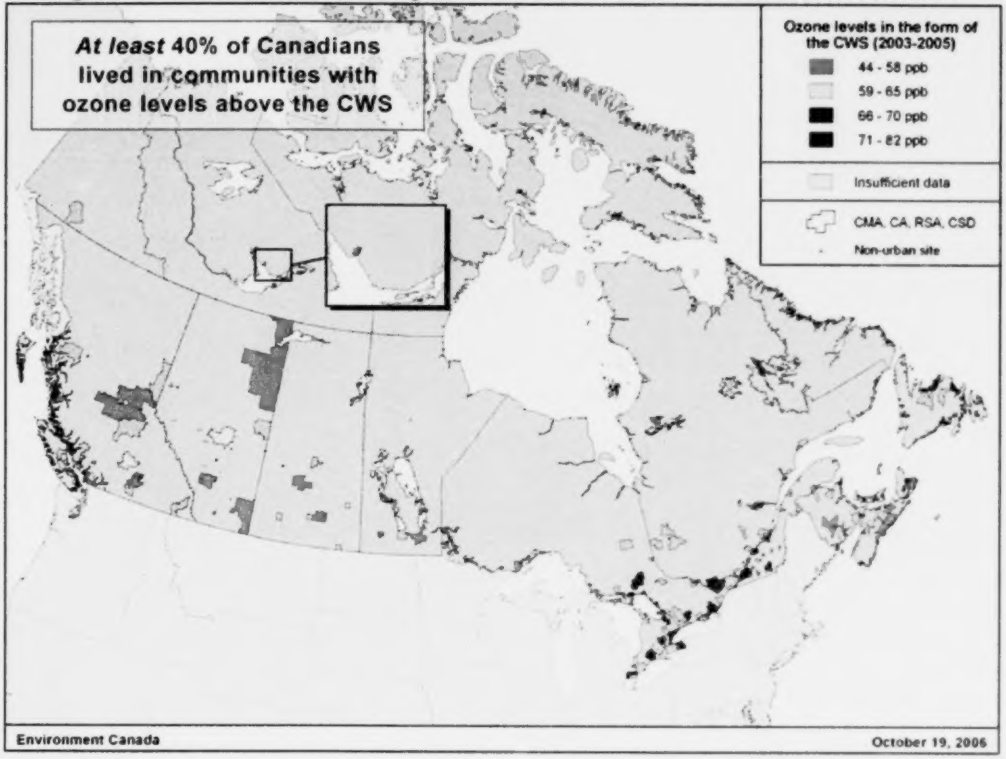
It should be noted that in many communities of Ontario and Quebec, levels of $PM_{2.5}$ and ozone above the numerical value of the CWS often occurred on the same days.

Figure 3: Ozone levels in the form of the CWS, 2003-2005



Notes: Shown are the values of the 3-year average of the annual 4th highest daily maximum 8-hour average ozone based on the procedures in the GDAD. Yellow band represents levels within 10% of the CWS. In blue with * are communities with populations of 100,000 or less that jurisdictions elected to report on. In *green italic* are non-urban monitoring stations. Data provided by provincial and territorial jurisdictions, and generated from measurements collected through NAPS. Data are preliminary and subject to change following further data quality assurance reviews.

Figure 4: Map of Canada showing ozone levels in the form of the CWS, 2003-2005



Notes: Shown are the values of the 3-year average of the annual 4th highest daily maximum 8-hour average ozone based on the procedures in the GDAD. Blue-hatched areas have insufficient data. Data provided by provincial and territorial jurisdictions, and generated from measurements collected through NAPS. Data are preliminary and subject to change following further data quality assurance reviews.

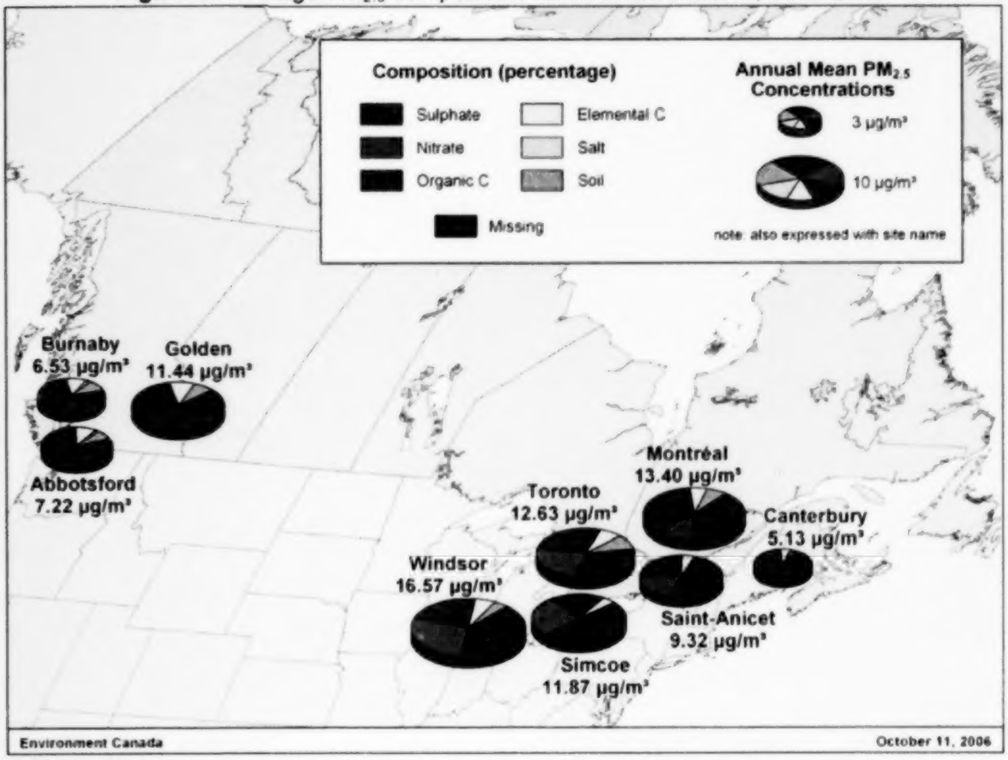
4.3 PM Composition

As noted in Section 2, particles typically consist of a mixture of substances. Information on the measured composition of the particles is important as it can be used in a *weight-of-evidence* approach to identify the source-categories contributing to the ambient PM mass. Health research is also increasingly pointing to the need to identify the PM components that may be responsible for the health effects.

Detailed measurements of the main PM species on a routine basis are relatively recent and are limited in coverage across Canada. This section presents results of a PM composition analysis for the current locations where PM speciation samplers are operated routinely.

Figure 5 provides an overview of the *average* $PM_{2.5}$ composition for stations in British Columbia (B.C.), Ontario, Quebec and New Brunswick from February 2003 to August 2005. During this period, total carbon (elemental + organic) was a major component of $PM_{2.5}$ mass in each location, followed by sulphate and nitrate (in their ammonium-related forms). Other minor components were soil elements and salt. Secondary $PM_{2.5}$ such as sulphate, nitrate and a portion of the organic carbon typically account for one half or more of the $PM_{2.5}$ mass in eastern locations. The B.C. locations generally reflected a greater predominance of total carbon than the eastern Canada locations. It should be noted, however, that the actual day-to-day composition may differ substantially from this average, depending on the sources that contributed to the $PM_{2.5}$ mass and the weather conditions that prevailed.

Figure 5: Average $PM_{2.5}$ composition for selected stations, 2003-2005



Notes: Data are for the period February 2003 to August 2005. Data generated by Environment Canada from measurements collected through NAPS. Sulphate and nitrate were assumed to be in their ammonium-related forms. For Simcoe and Saint-Anicet, the Soil fraction is part of "Missing," as estimates of the soil fraction were not possible for these two locations. The same applied for most soil measurement at Canterbury. Simcoe, Saint-Anicet and Canterbury are all in non-urban areas. The PM composition analysis is based on widely used mass-reconstruction methods.

4.4 Annual Variation in $PM_{2.5}$ Levels

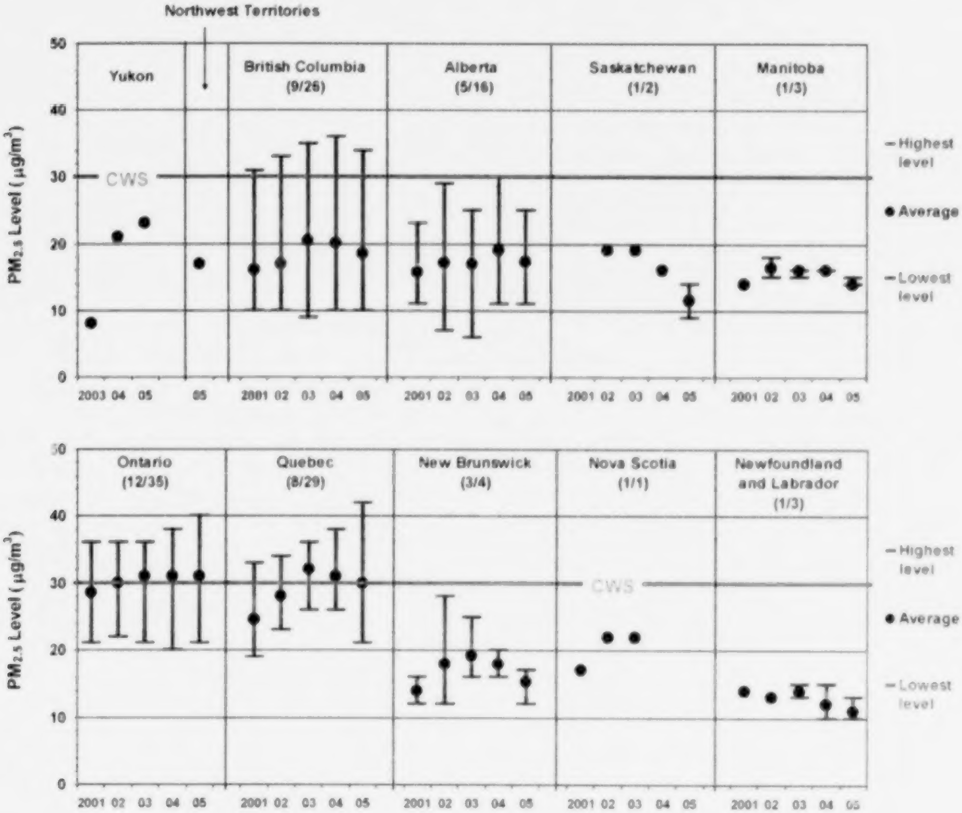
It is important to know the long-term trends in the ambient levels of $PM_{2.5}$ across Canada. However, *daily* monitoring of ambient $PM_{2.5}$ levels across all regions of Canada did not begin until the late 1990s, aided by the development and implementation of the CWS. As such, a sufficiently long-term record of data does not exist to enable the evaluation of robust trends in $PM_{2.5}$ levels. However, a qualitative indication of how the levels varied over the years is still possible. This is accomplished here by presenting the *regional range* in $PM_{2.5}$ levels in the form of the CWS for the period 2001 to 2005. The regional range for a given year is defined as being the lowest and highest values of all considered station-specific levels in the form of the CWS for that year, along with the average of all the station-specific levels.

From the late 1990s to 2005, the number of communities and areas covered by $PM_{2.5}$ monitoring grew rapidly. To provide a broad indication of the $PM_{2.5}$ levels that prevailed in the regions, the number of communities and areas considered here was not constant, but was rather allowed to vary yearly depending on the availability of the data. For this reason, and also because the $PM_{2.5}$ levels presented here are not to be used for CWS achievement evaluation, the number of communities and areas considered in this section are larger than those considered in Section 4.2. As such, the information in this section is not directly comparable to the information in Section 4.2.

Results

Figure 6 indicates the annual regional range (as defined above) in $PM_{2.5}$ levels in the form of the CWS. For most regions of Canada, average $PM_{2.5}$ levels ranged from 15 to 20 $\mu g/m^3$. Notable exceptions are Ontario and Quebec, where regional averages either neared the CWS or were above it. Ontario, Quebec and British Columbia are the three regions where the highest $PM_{2.5}$ level was above the CWS in every year. Elsewhere, the highest level was appreciably below the CWS except in Alberta and New Brunswick, where the highest levels approached the CWS in some years.

Figure 6: Regional ranges in $PM_{2.5}$ levels in the form of the CWS, 2001-2005



Notes: The $PM_{2.5}$ levels shown are from continuous monitors, consisting of the TEOM® (the majority) and BAM monitors. The highest and lowest levels shown are values of the 3-year average of the annual 98th percentiles of the daily 24-hour $PM_{2.5}$. These 3-year averages were computed for each monitoring station considered in the region and the highest and lowest of these were then extracted. The *Average* is simply the average of all the station-specific 3-year averages in the region. The numbers in brackets below the region's name (N1/N2) are the number of monitoring stations considered during the first (N1) and last (N2) year of the period; the number of stations considered for in-between years may have been fewer or more than these. Years with only a circle and no range shown indicates that only one station was considered, and therefore no range is possible. The monitoring method configuration may have changed over the years in some regions; this may have affected the monitoring results and may have contributed to the annual variation in levels. Data generated by Environment Canada from measurements collected through NAPS.

4.5 Trends in Ozone and Its Precursors

This section shows how the annual national and regional average levels of ozone and its precursors (NO, NO_2 and VOC) have varied over time. It also provides an estimation of the trends in these annual averages. The annual average for a given year is simply the average of all the considered station-specific values for that year (for both regional and national averages). These averages are based on data from monitoring stations with a 75% data capture over the period considered. The ozone averages are based on data from monitoring stations in both urban and non-urban areas, while for NO_x and VOC, only stations located in urban areas were considered (primarily because most measurements of NO_x and VOC occur in urban areas).

The values of the regional and national annual averages vary from year to year as the ambient levels react to changing conditions such as emissions and meteorology. Despite this variation, there may have been an overall upward or downward tendency in these values. This tendency is typically qualified by the slope (the rate of change) of a linear line fitted through the actual values, and it is this slope and the direction of change in values (*increasing* or *decreasing*) that is referred to as the *trend*.

In this report, the trend is estimated by applying the Sen's Non-parametric Estimator of Slope.[5] The Sen method was also used to test if a trend was statistically different from zero at the 95% confidence level. A non-statistically significant trend means that random variations alone may have been responsible for the trend and, as such, there is likely no systematic trend in levels. For this report, only the direction of the trend is indicated and trends that are not statistically significant are reported as *No trends*.

4.5.1 Trends in Ozone

Figure 7 shows how the annual national and regional average ozone levels in the form of the CWS varied over the 15-year period from 1991 to 2005. Except for New Brunswick, national and regional average ozone levels have remained more or less unchanged (i.e. the trends were not statistically different from zero) over the 15-year period. Levels in New Brunswick experienced a decreasing trend, although this is largely attributable to the substantial drop in levels at the beginning of the period.

> The "no change" observed in ozone levels over the 15-year period would suggest a corresponding "no improvement" in population health risk associated with ambient ozone levels in the form of the CWS.

Figure 7 also shows how the average ozone levels compare to the numerical value of the CWS. This is shown only as a relative indication of the magnitude of the measured levels, and not as an indication of achievement of the CWS. The national average ozone levels were either just above or just below the CWS over most of the 15-year period. In the four western provinces, the regional averages have been consistently below the CWS, with the highest levels found in Alberta. The regional average has been above the CWS every year in Ontario, and in all but two years in Quebec.

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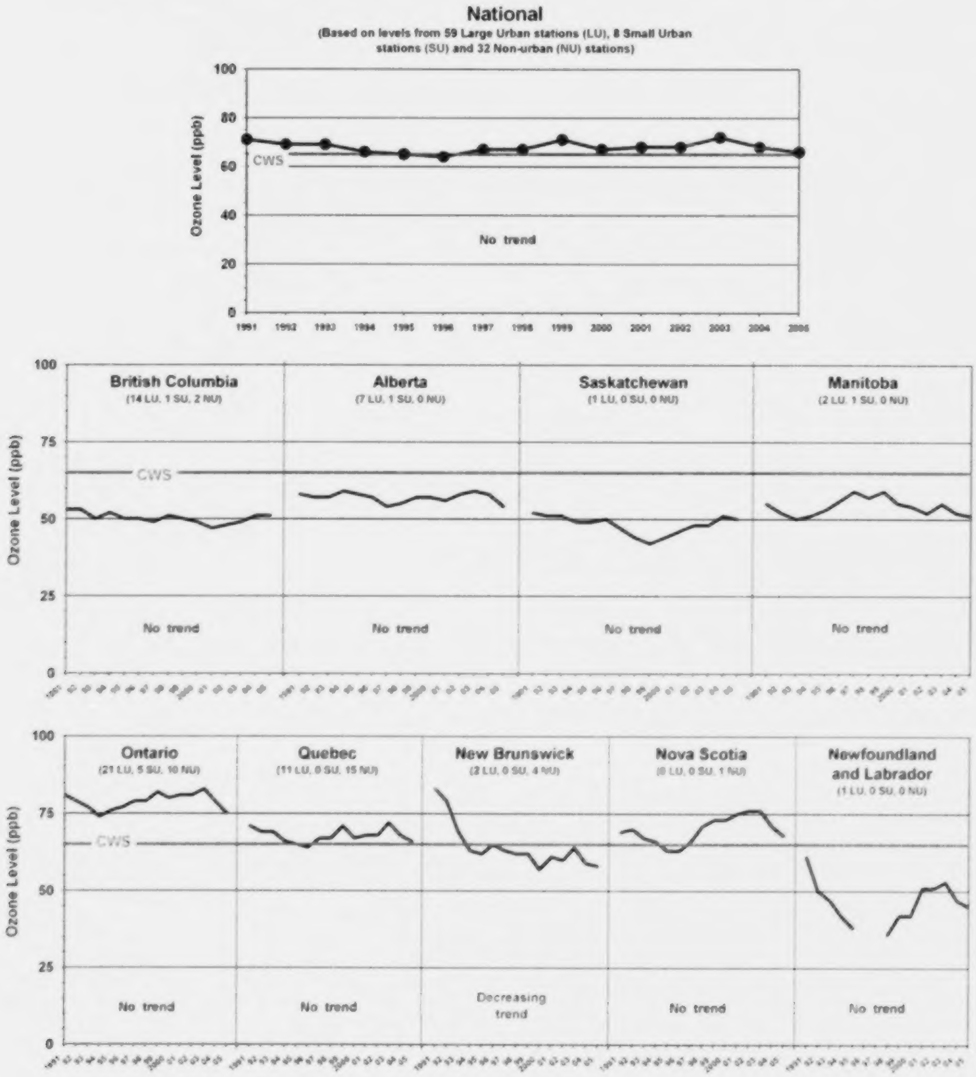
[5] Sen, P.K. 1968. Estimates of the regression coefficient based on Kendall's tau. Journal of the American Statistical Association. 63:1379–1389.

Figure 7: Trends in ozone levels in the form of the ozone CWS, 1991-2005



Notes: Indicated levels are consecutive 3-year averages. The ozone CWS is shown only as an indication of how the levels compare, on average, to the Standard and not as an indication of achievement of the CWS over the years. The direction of the trend in levels (decreasing or increasing) is indicated only if the obtained value of the trend is statistically different from zero at the 95% confidence level. Otherwise it is indicated as "No trend." Data generated by Environment Canada from measurements collected through NAPS. Large urban (LU) stations are located in communities with populations over 100,000; Small urban (SU) stations are located in communities with populations of 100,000 or less; Non-urban (NU) stations are located in areas where the land use is predominantly rural.

In New Brunswick, the average was above the CWS at the beginning of the period, and has remained just below it ever since. For Nova Scotia, only one non-urban monitoring station (located in Kejimkujik National Park) satisfied the data completeness criteria. The ozone levels at this station have been mostly above the CWS. For Newfoundland and Labrador, the only station considered, located in St. John's, has had ozone levels consistently below the CWS. Overall, levels in the eastern regions have experienced a downward tendency over the last three years of the reporting period.

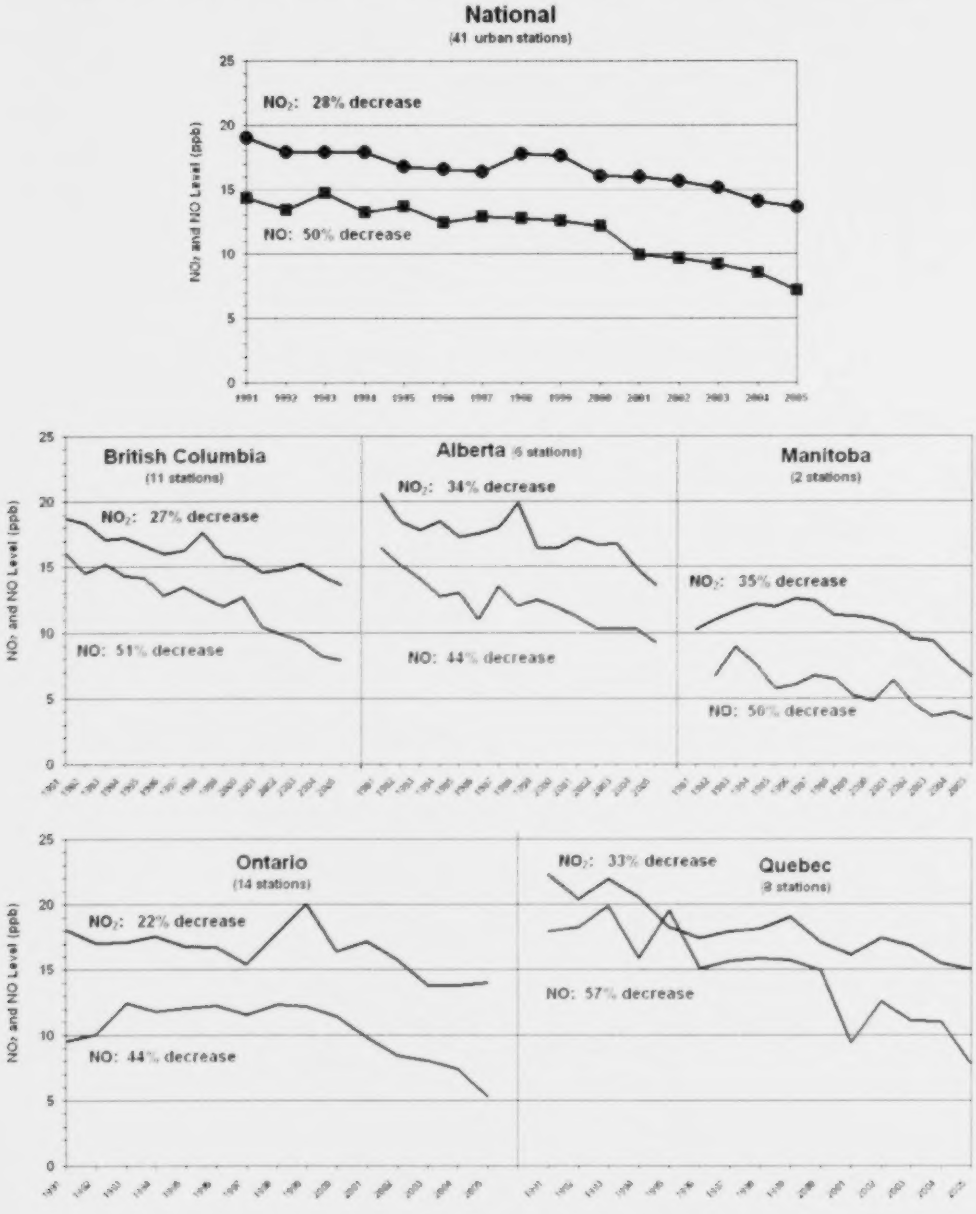
4.5.2 Trends in NO_X

Figure 8 shows how the annual warm season (April to September) national and regional average of the 1-hour NO and NO_2 levels varied over the 15-year period 1991 to 2005. April to September is the period in Canada where the peak short-term (1- to 8-hour averages) ozone levels are typically the highest. The ambient NO and NO_2 levels discussed here are based only on monitoring stations located in urban communities and are presented only for regions with sufficient data.

The ambient NO and NO_2 levels both decreased substantially, nationally and regionally, with statistically significant downward trends. Nationally, NO levels in 2005 were about 50% lower than in 1991, and NO_2 about 30% lower. Similar reductions are also seen in each considered region. Of interest to note in Figure 8 is the fact that reductions in NO were almost double those of NO_2.

Since only urban monitoring stations were considered, the measured ambient NO and NO_2 levels at these stations is largely a reflection of locally generated emissions of NO_X. For most Canadian urban areas the largest sources of NO_X emissions come from on-road vehicles. As such, the observed reductions in ambient NO appears to be consistent with the NO_X reductions from on-road vehicles of about 40% between the 1990 emissions and the projected emissions for 2005 (see Section 6.2.2).

Figure 8: Trends in 1-hour NO_2 and NO levels, April to September, 1991-2005



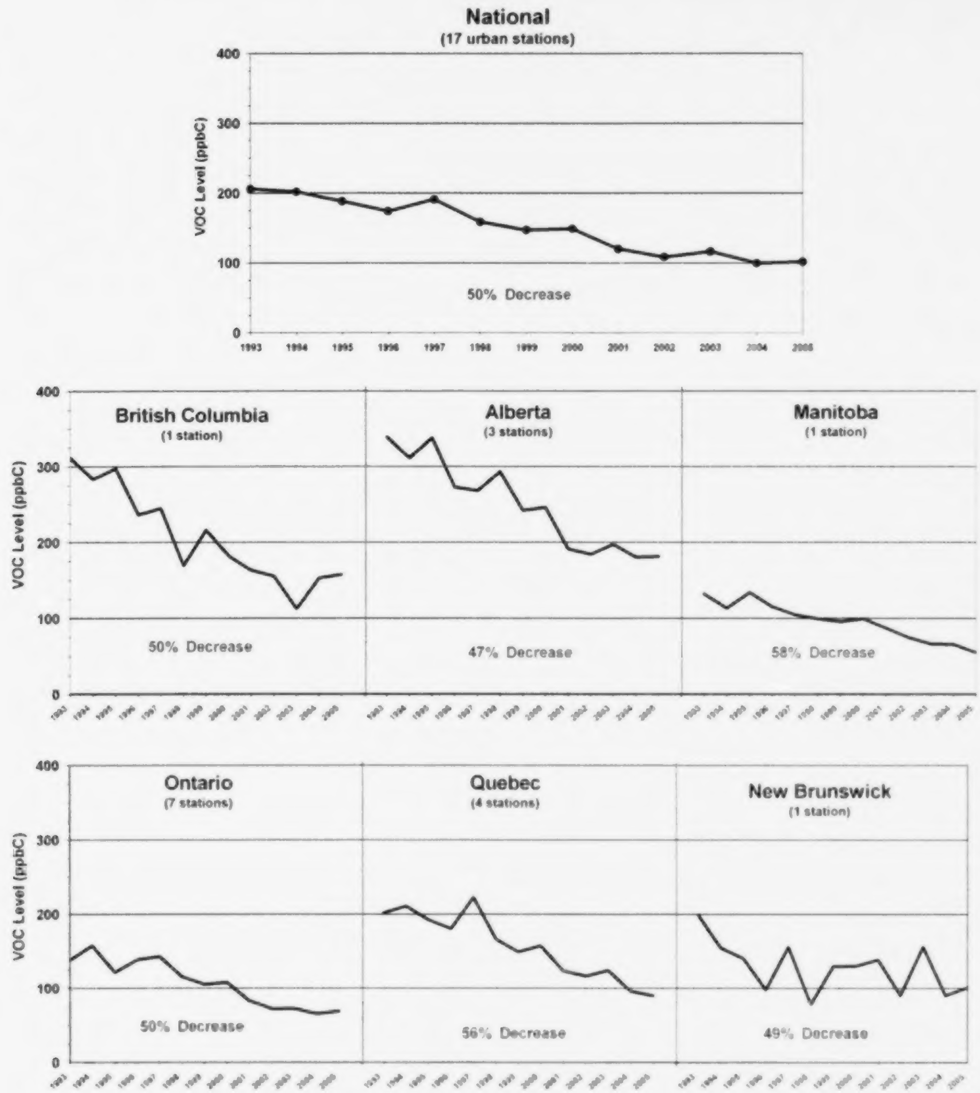
Notes: Downward trends are observed in all regions for both NO_2 and NO and these trends are all statistically signficant at the 95% confidence level. The indicated percentage changes are the percentage difference in levels between the end year and the beginning year. In brackets are the number of Large Urban stations considered. Data were generated by Environment Canada from measurements collected through NAPS.

4.5.3 Trends in VOC

Ambient VOC levels are not measured every hour like NO and NO_2. Rather, they are measured over a 24-hour period, with the measurements taken every three or six days. This section shows how the annual warm season (April to September) national and regional average of these levels varied over the period 1993 to 2005 (the longest period of available data for a larger number of monitoring stations). The VOC levels discussed here are based only on monitoring stations located in urban communities and are presented only for regions with sufficient data.

As seen in Figure 9, ambient VOC levels decreased both nationally and regionally by about 50%. The decreasing trend was (statistically) significant nationally and in all regions except at the New Brunswick monitoring station. The decrease in ambient VOC appears to be consistent with the VOC emission reductions from on-road vehicles of about 50% between the 1990 emissions (676 kilotonnes, kt), and the projected emissions in 2005 (274 kt).

Figure 9: Trends in 24-hour VOC levels, April to September, 1993-2005



Notes: Downward trends are observed in all regions and the trends are all statistically signficant (95% confidence level), except for New Brunswick where the trend is not statistically significant. The indicated percentage changes are the percentage difference in levels between the end year and the beginning year. In brackets are the number of Large Urban station considered. Data were generated by Environment Canada from measurements collected through NAPS.

4.5.4 Discussion on Trends

As noted above, national average ozone levels in the form of the CWS (which considers the 4th highest ozone levels) remained unchanged over the 15-year period from 1991 to 2005. During this time period, ambient levels of ozone precursors decreased substantially. The decrease in ambient NO levels at many urban locations, with a resulting decrease in ozone scavenging (as discussed in Section 2), is the most apparent reason why the 4th highest ozone levels remained unchanged. There are also substantial year-to-year variations in the higher ozone levels resulting from the yearly change in meteorological conditions. These not only have substantial impacts on the higher ozone levels, but they also mask the long-term trends in ozone levels associated with changes in emissions of NO_X and VOC.

Ozone levels measured at a given location depend not only on the emissions of the precursors in the community, but also on a number of other factors such as the prevailing meteorological conditions, the chemical processes, the direction of the wind and the associated possible transport of ozone and its precursors into the community from upwind source regions, and the long-range transport of these pollutants. As such, comparison between the local ozone levels and the local ambient levels of its precursors alone is not sufficient to account for trends in ozone levels.

Modelling and observational analysis continue to support the view that reductions in both VOC and NO_X will benefit urban areas while NO_X reductions may be more effective in lowering widespread ozone concentrations, benefiting rural areas.

4.6 Canada–U.S. Border Regions

This section presents information on ambient $PM_{2.5}$ and ozone levels for monitors within 500 km of the border between Canada and the lower 48 states of the U.S., as well as information on trends in ozone levels and precursors (May to September) for specified regions along the Canada–U.S. border. For ozone and its precursors, the presented information is in alignment with the joint reporting commitment of Canada and the U.S. under the *Canada–United States Air Quality Agreement*[6] (see Section 5.6).

4.6.1 $PM_{2.5}$ Levels

Figure 10 displays the 3-year average of the annual 98th percentiles of the 24-hour $PM_{2.5}$ levels for monitors located within 500 km of the border between Canada and the lower 48 states of the U.S. The indicated levels are for the period 2002-2004, and only stations with a 98th percentile available in all three years were considered.[7] The $PM_{2.5}$ levels were measured by a filter-based manual sampler in the U.S. and by a continuous monitor in Canada.[8]

Figure 10 indicates that the higher $PM_{2.5}$ levels mostly occurred in the Lower Great Lakes–Ohio Valley region, along the U.S. east coast, and along the Windsor–Québec City Corridor. In these regions, levels were mostly above 30 µg/m³, as were some stations along the west coast. No monitors recorded levels above 65 µg/m³.

The U.S. and Canadian $PM_{2.5}$ 24-hour Standards**

U.S. Standard: 65 µg/m³

CWS: 30 µg/m³

The form of the U.S. Standard and the CWS is the same.

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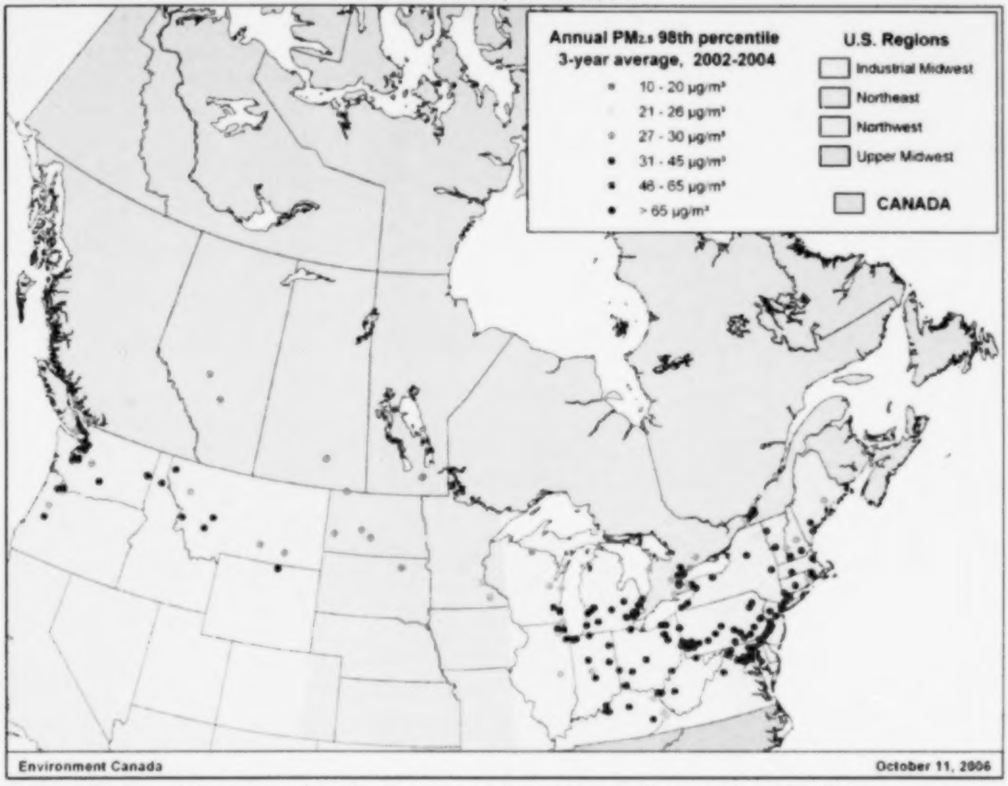
[6] There is no reporting requirement for $PM_{2.5}$ under the Canada–U.S. Agreement.

[7] 98th percentiles were retained only if the data completeness was 75% in each calendar quarter.

[8] The instruments used are the Federal Reference Method samplers in the U.S. and the Tapered Element Oscillating Microbalance monitor (TEOM®) in Canada.

** The U.S. also has an *annual* National Ambient Air Quality Standard (NAAQS) for $PM_{2.5}$ (15 µg/m³, 3-year average). At the time of publication of this report, the U.S. EPA issued a revision to the NAAQS for $PM_{2.5}$. The 24-hour Standard was revised from 65 to 35 µg/m³, while the existing annual NAAQS was retained. For more information, see http://epa.gov/pm/pdfs/20060921_factsheet.pdf

Figure 10: The 3-year averages of the annual $PM_{2.5}$ 98th percentiles along the Canada–U.S. border, 2002-2004



Notes: Shown are the values of the 3-year average of the annual 98th percentiles of the 24-hour average $PM_{2.5}$ for monitoring stations located within 500 km of the border between Canada and the lower 48 states of the U.S. Data generated by Environment Canada from measurements collected through NAPS in Canada and from information obtained from the EPA Air Quality System (AQS) Database for the U.S.

4.6.2 Ozone Levels

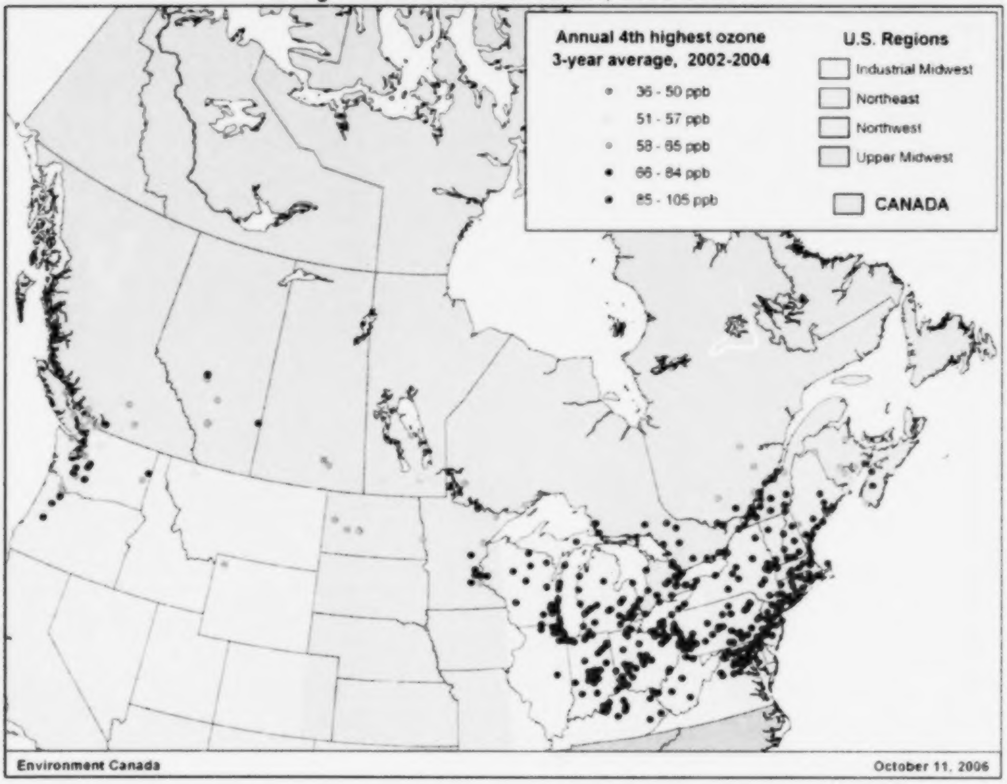
Figure 11 displays the 3-year average of the annual 4th highest daily maximum 8-hour ozone levels for monitoring stations located within 500 km of the border between Canada and the lower 48 states of the U.S. The levels are for the period 2002-2004, and only monitors with an annual 4th highest daily maximum 8-hour ozone available in all three years were considered.[9]

[9] The annual 4th highest daily maximum 8-hour ozone was retained only if the data completeness was 75% in the combined 2nd and 3rd calendar quarters.

Figure 11 indicates that the higher ozone levels mostly occurred in the Lower Great Lakes–Ohio Valley region, along the U.S. east coast, and along the Windsor–Québec City Corridor. In these regions, levels were mostly above 65 ppb, and many stations in these U.S. regions recorded levels of 85 ppb and above. Some stations in Atlantic Canada and in the western regions also recorded levels above 65 ppb.

> **U.S. and Canadian Ozone Standards**
>
> **U.S. Standard:** 0.08 ppm
>
> **CWS:** 65 ppb (0.065 ppm)
>
> The form of the U.S. Standard and the CWS is the same.

Figure 11: The 3-year average of the annual 4th highest daily maximum 8-hour ozone along the Canada–U.S. border, 2002-2004



Notes: Shown are the values of the 3-year average of the annual 4th highest daily maximum 8-hour ozone for monitoring stations located within 500 km of the border between Canada and the lower 48 states of the U.S. Data generated by Environment Canada from measurements collected through NAPS in Canada and from information obtained from the EPA Air Quality System (AQS) Database for the U.S.

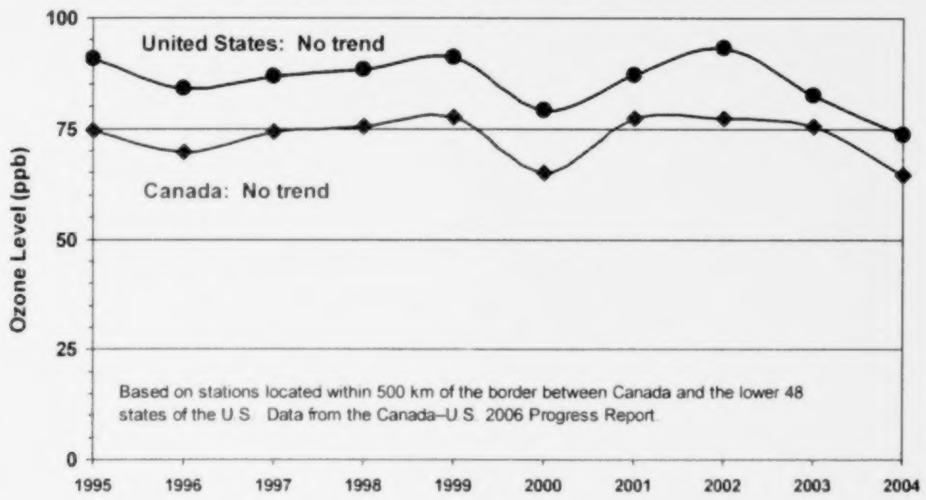
4.6.3 Trends in Ozone and Its Precursors

This section shows how the levels of ozone and its major precursors (NO_X and VOC) varied over time (up to 10 years from 1995 to 2004). The Sen non-parametric method[10] was used to estimate the trend in levels (i.e. the slope of a linear-estimate line) and whether or not the trend was statistically significant at the 95% confidence level. The Sen slope estimator is the same as the Theil estimator used by the EPA in the *National Air Quality and Emissions Trends Report, 2003 Special Studies Edition*. The methods differ slightly in testing for statistical significance.

Trends in Ozone

Figure 12 shows how the regional average annual 4th highest daily maximum 8-hour ozone levels have varied over time (1995-2004) based on monitors within 500 km of the border between Canada and the lower 48 states of the U.S. The Sen test indicates a small decreasing trend in levels for both the U.S. and Canada. However, these trends were not found to be statistically significant. To note in Figure 12 is the similar temporal pattern in levels in both regions and the decrease in levels from 2002. Part of this decrease could be due to a cool and rainy summer of 2004 in eastern North America. There are also complex regional patterns in both Canada and the U.S. that are not evident from Figure 12.

Figure 12: Trends in the regional average annual 4th highest daily maximum 8-hour ozone along the Canada–U.S. border, 1995-2004



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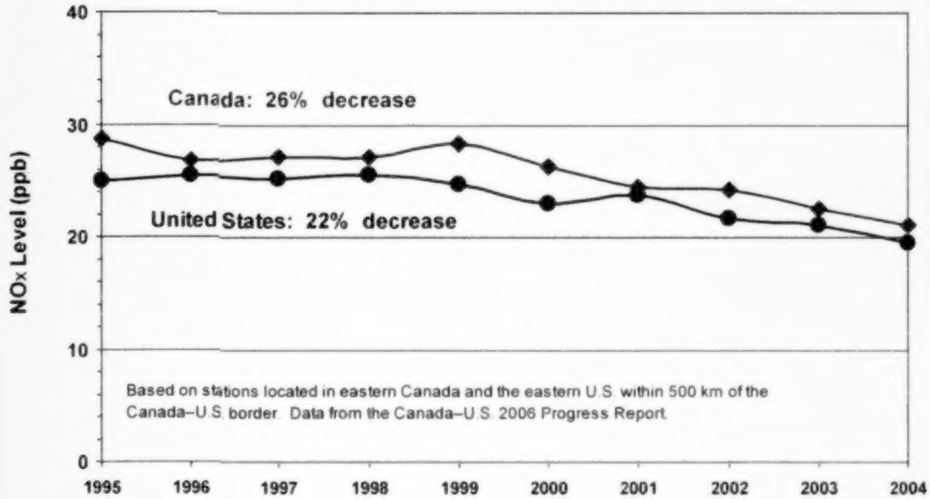
[10] Sen, P.K. 1968. Estimates of the regression coefficient based on Kendall's tau. Journal of the American Statistical Association. 63:1379–1389.

Trends in NO_X

Figure 13 shows how the regional average 1-hour NO_X levels for the May to September period have varied over time (1995-2004) based on monitors located within 500 km of the border in the eastern U.S. and eastern Canada (primarily the PEMA region discussed in Section 5.6).

Over the 10-year period 1995 to 2004, the 1-hour NO_X levels decreased in both countries with statistically significant downward trends. Compared to 1995, levels in 2004 were 22% lower in the U.S. and 26% lower in Canada.

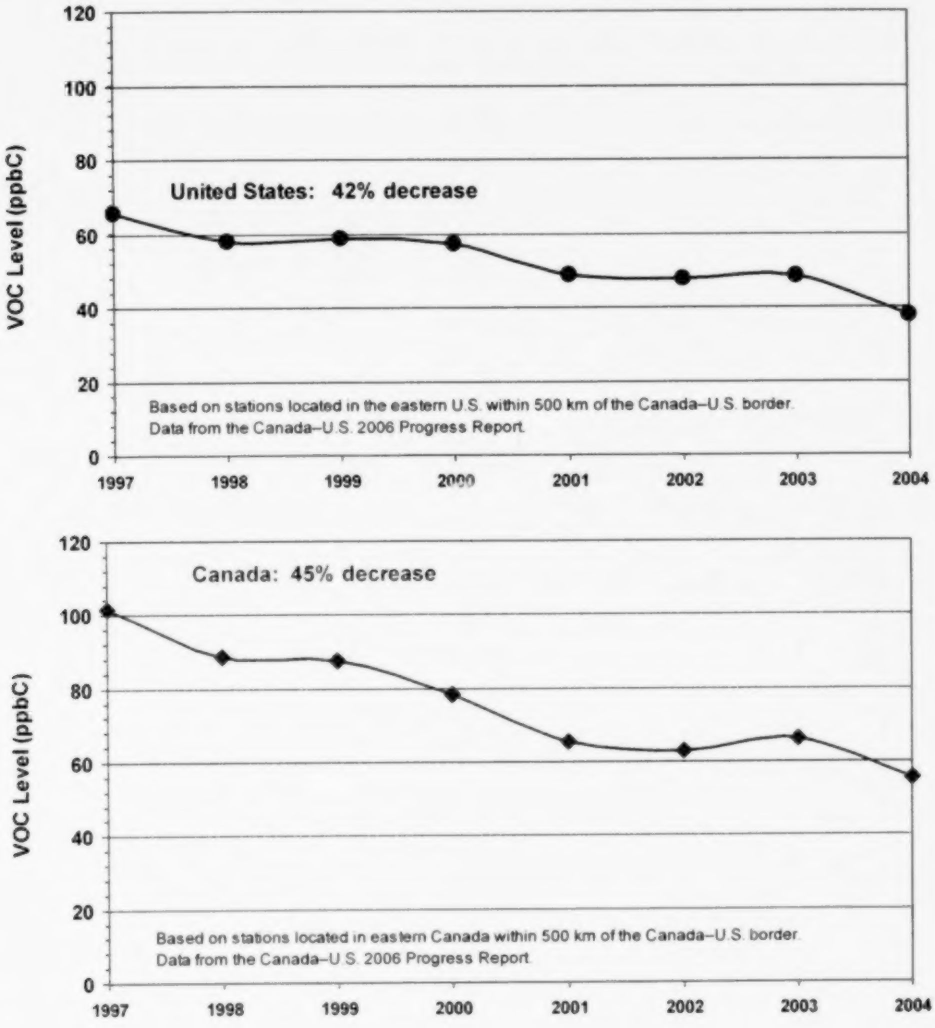
Figure 13: Trends in the regional average 1-hour NO_X levels along the Canada–U.S. border, May to September, 1995-2004



Trends in VOC

Figure 14 shows how the regional average 24-hour VOC levels for the May to September period have varied over time (1997-2004) based on monitors located within 500 km of the border in the eastern U.S. and eastern Canada. The levels are presented on separate charts to avoid direct comparison between the two countries because the monitoring site groups considered are too different to allow such direct comparisons. Over the eight-year period 1997 to 2004, VOC levels decreased in both countries, with the downward trend being statistically significant. Compared to 1997, levels in 2004 were 42% lower in the U.S. and 45% lower in Canada.

Figure 14: Trends in the regional average 24-hour VOC levels along the Canada–U.S. border, May to September, 1997-2004



Discussion

For Canada–U.S. border regions, trends in ozone and its precursors for the 10-year period 1995 to 2004 were similar to those of Canadian regions for the 15-year period 1991 to 2005. That is, ozone levels (the annual 4th highest daily-maximum 8-hour ozone) remained statistically unchanged, while the ambient levels of its precursors decreased. However, as mentioned in Section 4.5.4, modelling and observational analyses continue to support the view that reductions in both NO_X and VOC will benefit urban areas, while NO_X reductions may be more effective in lowering the regional ozone levels, also benefiting rural areas.[11]

Summary of Section 4

For the period 2003-2005, at least 30% of the Canadian population lived in communities where levels of $PM_{2.5}$ were above the CWS, and at least 40% lived in communities where levels of ozone were above the CWS. Most of these communities were in Ontario and Quebec, and a few were in British Columbia. Many other communities across Canada were within 10% of the level of the Standards.

For border regions of the U.S. and Canada, the highest $PM_{2.5}$ and ozone levels for the period 2002-2004 occurred mostly in the Lower Great Lakes–Ohio Valley region, along the U.S. east coast and along the Windsor–Québec City Corridor, with levels generally being higher in the U.S. portions of these regions. This is typical of other years as well.

For both Canada and the U.S., regional average ozone levels (based on the 4th highest levels) have remained statistically unchanged, while ambient levels of the precursors decreased. The decrease of ambient NO levels at many urban locations, with a resulting decrease in ozone scavenging, is the most apparent reason why the levels remained unchanged. Modelling and observational analysis continues to support the view that NO_x reductions are more effective in reducing the regional ozone levels, while further emission reductions in both NO_x and VOC will benefit urban areas.

The "no change" in the regional-average ozone levels would also suggest a "no improvement" in the general population health risk associated with ozone levels in the form of the CWS.

[11] Analysis conducted by the EPA in the September 2006 report entitled *NOX Budget Trading Program, 2005 Program Compliance and Environmental Results* (report EPA430-R-06-103) indicates that there is a strong association between areas of the eastern U.S. with the greatest reductions in NO_X emissions and nearby downwind sites exhibiting the greatest improvements in ozone.

5. SMOG MANAGEMENT EFFORTS

The Government of Canada published its *Interim Plan 2001 on Particulate Matter and Ozone* (Interim Plan 2001) in 2001,[12] followed by a progress report in 2003.[13] The Interim Plan 2001 outlined a series of short- and longer-term measures with the primary objective of helping to achieve the CWS. The plan was designated as *Interim* in recognition of the fact that protecting human health and the environment from the adverse effects of PM and ozone will require an evolving series of measures, based on such considerations as emerging science, technology and socio-economic factors.

Smog management measures initiated under the Interim Plan 2001 reflected a combination of approaches. Some of these, as in the transportation sector, were largely regulatory in nature. Others, such as the Multi-pollutant Emission Reduction Strategies (MERS) – one of several Joint Initial Actions (JIAs) under the CWS for selected industrial sectors – were based on a cooperative approach with other jurisdictions.

The Government of Canada also made use of diverse programs and policies to strengthen its emission reduction efforts. For example, the federal government added PM_{10} (in 2001) and ozone, sulphur dioxide, nitrogen oxides, volatile organic compounds, and gaseous ammonia (in 2003) to Schedule 1 of the *Canadian Environmental Protection Act* (CEPA), *1999*. A series of investments were also made in research and innovation, monitoring networks, and public outreach. The Interim Plan 2001 also reflected a commitment to using voluntary measures such as codes of practice and pollution prevention planning.

In combination, these measures have played an important role in developing instruments for reducing or minimizing emissions. Together with measures by other jurisdictions, these federal actions have contributed to progress toward the goals of the CWS of keeping clean areas clean, continuous improvement, and the achievement of the PM and ozone CWS by 2010.

This section outlines progress made since 2000 in key domestic areas such as transportation, consumer and commercial products, and industrial sectors.

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[12] http://www.ec.gc.ca/cleanair-airpur/CAOL/air/interim2001/minister_e.html

[13] http://www.ec.gc.ca/CEPARegistry/documents/agree/PM_resp_03/PM_resp_03_e.pdf

5.1 Transportation Sector

The Interim Plan 2001 reiterated an earlier federal commitment to implement the Agenda on Cleaner Vehicles, Engines and Fuels (released in February 2001), recognizing that in 2000 the transportation sector was the largest contributor to total national anthropogenic emissions of NO_X and VOC in Canada. Transportation accounted for more than half of all NO_X emissions and more than one third of all VOC emissions. Because of the sulphur present in fuels, the transportation sector is also a source of SO_2.

Transportation Sector

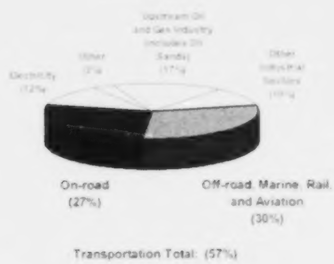
This sector includes On-road Vehicles, Off-road Vehicles and Engines, Marine Vessels, Rail, and Aviation.

On-road Vehicles are all motorized vehicles driven "on-road." They include cars, minivans, SUVs, trucks, buses and motorcycles.

Off-road Vehicles *and* ***Engines*** are vehicles not used on-road, together with motorized equipment. They include agricultural, mining and construction vehicles and equipment, all-terrain vehicles, snowmobiles, recreational watercraft, lawnmowers, and leaf blowers.

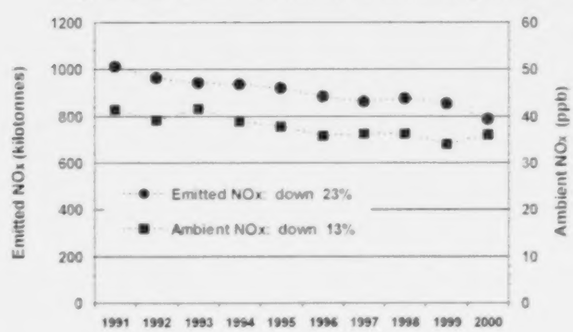
Marine Vessels, ***Rail*** and ***Aviation*** includes all emissions from aircraft, commercial marine vessels and locomotives.

NO_x Anthropogenic Emissions (2,456 kilotonnes), Sector Contributions - 2000
(excludes Open Sources)

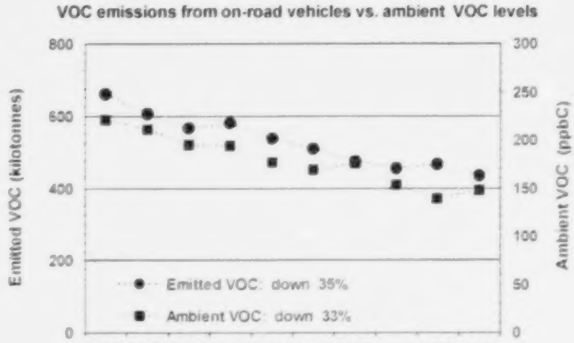


VOC Anthropogenic Emissions (2,211 kilotonnes), Sector Contributions - 2000
(excludes Open Sources)

NO_X emissions from on-road vehicles vs. ambient NO_X levels



VOC emissions from on-road vehicles vs. ambient VOC levels



Previous regulations for the transportation sector have resulted in appreciable reductions in emissions of NO_X and VOC. These emission reductions have resulted in similar reductions in ambient levels of NO_X and VOC in urban areas, as shown in the two charts to the right.

Actions taken by the Government of Canada to reduce emissions from the transportation sector include regulations and other measures for on-road vehicles, off-road vehicles and engines, and fuels. Many of these actions are aligned with those initiated by the U.S. EPA. The text below provides an outline of these actions.

On-road Vehicles, Off-road Vehicles, Engines and Fuels

Since 2001, a number of regulations have been implemented or initiated to reduce emissions from on-road and off-road vehicles and engines. The Government of Canada has also established fuel quality regulations to reduce emissions of smog-producing pollutants and CEPA toxic substances from the burning or evaporation of fuels. Regulations implemented to date include the following:

Sulphur in Gasoline Regulations. These regulations limit the sulphur content of gasoline. Interim limits came into force in 2002, and the final limits in 2005 (30 mg/kg annual average, and 80 mg/kg maximum).

Gasoline and Gasoline Blend Dispensing Flow Rate Regulations (in force in 2001). These regulations enable vapour emissions of benzene and other VOC to be reduced by 95% during the refuelling of light-duty vehicles and trucks when the fuel dispensing flow rate is limited to a maximum of 38 litres per minute.

Sulphur in Diesel Fuel Regulations (2002). These regulations limit the sulphur content in diesel fuel used in on-road, off-road, rail and marine applications.

On-road Vehicle and Engine Emission Regulations (2004). These regulations came into force on January 1, 2004, to introduce new stringent national emission standards for 2004 and later model-years of light-duty vehicles, light-duty trucks, heavy-duty trucks and engines, and motorcycles.

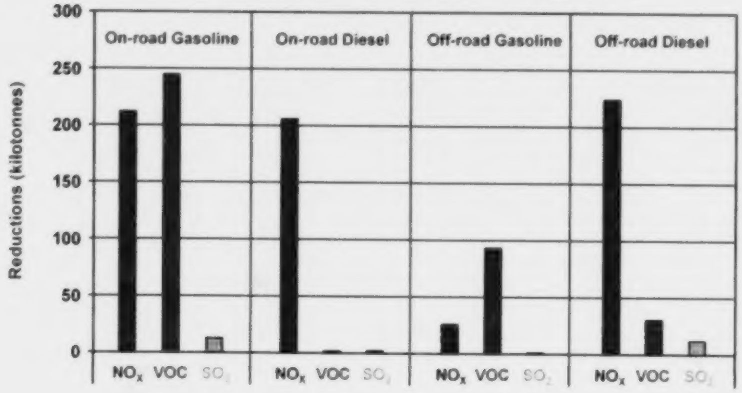
Off-road Small Spark-ignition Engine Emission Regulations (2005). These regulations establish emission standards for 2005 and later model-year engines rated up to 19 kilowatts (e.g. lawnmowers, light-duty industrial machines, and light-duty logging machines).

Off-road Compression-ignition Engine Emission Regulations (2006). These regulations came into force on January 1, 2006, and set more stringent emission limits for hydrocarbons, carbon monoxide and PM from equipment used in construction, agricultural, mining and forestry operations.

For more information on the above regulations, please consult:
http://www.ec.gc.ca/CEPAregistry/regulations/

These regulations will see emissions decline even further over the next several years. When fully implemented by 2020, these regulations will result in projected emission reductions on an annual basis of more than 670 kt for NO_X, 360 kt for VOC and 30 kt for SO_2 compared to their emissions in 2000 (see Section 6 for more details).

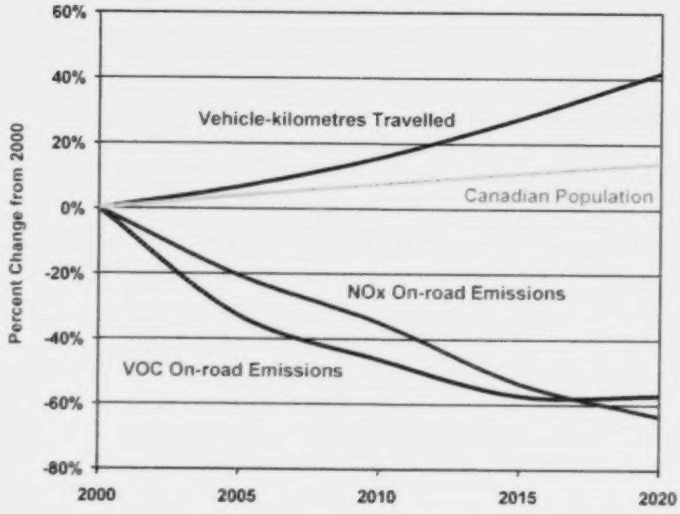
Annual Emission Reductions (from 2000) at Full Implementation (by 2020) of Federal Transportation Regulations



Source: Environment Canada, February 2006

However, as the Canadian population grows, projections suggest that increases in the number of vehicle-kilometres travelled by on-road vehicles will begin to offset the emission reduction benefits from these regulations. Emissions could even begin to increase again if no further actions are taken.

Relative Changes in National On-road NO_X and VOC Emissions with Respect to Population Growth



Source: Environment Canada, February 2006

Marine Vessels, Rail and Aviation

Given the significant growth projected in these three sub-sectors (particularly marine traffic), the Interim Plan 2001 announced initiatives and actions for reductions in their emissions.

Partly because of the significant progress made in reducing emissions from on-road vehicles over the last decade, smog-producing emissions from marine vessels are projected to surpass those from on-road vehicles in some coastal areas of the country. In recognition of these projections, the federal government and the United States have been jointly exploring the possibility of having parts of the North American coast (and navigable waterways such as the Great Lakes and the St. Lawrence Seaway) declared as Special Areas, in which the sulphur content of marine fuels would be restricted to 1.5% from 4.5% (the current standard outside of Special Areas).

Regarding rail, between 1995 and 2005 a Memorandum of Understanding (MOU) was in place between Environment Canada and the Railway Association of Canada (RAC). This MOU, which expired in December 2005, included a cap on NO_X emissions from locomotives at 115 kt. On average, annual NO_X emissions have stayed below the cap despite a 21% increase in rail traffic over the same period. Environment Canada and Transport Canada have initiated discussions with the RAC to develop a new voluntary agreement as the 1995 agreement expired in 2005.

Transport Canada represents the federal government on the International Civil Aviation Organization's (ICAO) Committee on Aviation Environmental Protection (CAEP). Transport Canada has played a leadership role in this forum by chairing or co-chairing CAEP working groups and by leading efforts to promote ICAO/CAEP guidance to the international community. In particular, Transport Canada was instrumental in the development and promotion of the ICAO Circular *Operational Opportunities to Minimize Fuel Use and Reduce Emissions* and has supported workshops to disseminate these best practices. In addition, based on the work of CAEP, the ICAO recently adopted new NO_x emission standards, which are 12% more stringent than previous levels agreed to in 1999. Transport Canada also invests in research to better understand the air quality impacts of aircraft and airports.

Transport Canada has also been conducting air quality studies for many years and is in the process of completing a 12-month sampling campaign at a major Canadian airport. Transport Canada has also joined forces with the U.S. Federal Aviation Administration (FAA) and the National Aeronautics and Space Administration (NASA) to sponsor a Centre of Excellence called Partnership on AiR Transportation Noise and Emissions Reduction (PARTNER). PARTNER is a coordinated effort of governments, industry and academia that seeks to enhance the understanding of aviation environmental issues and foster breakthrough technical, operational, and workforce capabilities enabling a quieter and cleaner aviation sector. Transport Canada also concluded a voluntary agreement with the Air Transport Association of Canada (ATAC) in May 2005 to limit the growth of greenhouse gas emissions from the aviation industry. This agreement, which sets concrete targets, an action plan and reporting mechanisms, is the first of its kind in the world.

Other Transportation Initiatives and Measures

The Government of Canada is also engaged in voluntary measures to combat smog-producing emissions from the transportation sector. Some of these include:

Vehicle Testing: In some regions of Canada, provinces require periodic vehicle emissions testing as part of their licensing requirements. These include *AirCare*[14] for the Lower Fraser Valley (including Vancouver) in British Columbia, and *Drive Clean*[15] for parts of Ontario. Environment Canada has operated *Let's Drive Green* vehicle emissions testing clinics during the summer months in a number of communities where mandatory testing programs are not in place. These clinics provide an important opportunity to raise public awareness of the significant emissions from vehicles.

Scrappage Programs: Although older vehicles constitute only 10% to 15% of all on-road vehicles in Canada, they account for approximately half of all smog-forming emissions from these vehicles. As a result, Environment Canada continues to support voluntary vehicle scrappage programs in a number of communities to accelerate the removal of these vehicles from Canadian roads. Under these programs, qualified owners of pre-1994 model year vehicles can choose to scrap their vehicle in exchange for one of the incentives offered in their communities, which may include transit passes, rebates toward the purchase of a new or newer vehicle, or rebates toward the purchase of a bicycle. Environment Canada collaborates with scrappage programs in the communities of Vancouver, Kelowna, Calgary, Edmonton, Winnipeg, Montréal, Québec, Halifax, and major centres in New Brunswick.

World Forum for Harmonization of Vehicle Regulations: Transport Canada and Environment Canada participate in the UNECE *World Forum for Harmonization of Vehicle Regulations.*[16] A new Global Agreement was created in 1998 to promote the development of harmonized Global Technical Regulations worldwide. There are various emerging technologies to improve the performance of on-road vehicles. Early adoption of progressive global standards could speed up their progress, reduce overall development and certification costs, and thereby facilitate their global introduction.

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[14] http://www.aircare.ca/
[15] http://www.driveclean.com/
[16] http://www.unece.org/trans/main/wp29/wp29wgs/wp29gen/wp29age.html

5.2 Consumer and Commercial Products

The Interim Plan 2001 stated the federal government's intention to develop an agenda to address emissions from the consumer and commercial products sector, including emissions of volatile organic compounds (VOC) from solvents, and emissions from residential wood combustion appliances. This section provides an update on initiatives and actions undertaken for these two sub-sectors.

Consumer and Commercial Product Sector

This sector consists of ***Solvent Use*** and ***Residential Wood Combustion Appliances***.

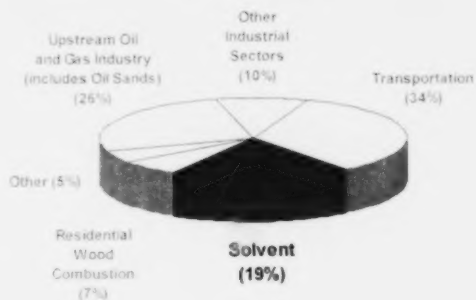
Solvents include household and industrial cleaners, degreasers, personal care items, adhesives and paints.

Residential Wood Combustion includes appliances burning fuelwood such as woodstoves and fireplaces.

Solvents

Emissions from solvents used in consumer and commercial products are a major source of VOC in Canada. In 2000, they were the third largest (19% of total) after the transportation sector (34%) and the upstream oil and gas industry (26%). In recognition of the significance of consumer and commercial products as sources of VOC, the Government of Canada committed in its Interim Plan 2001 to develop a federal action plan to reduce VOC emissions from these products.

VOC Anthropogenic Emissions, Sector Contributions - 2000
(excludes Open Sources)



Total: 2,211 kilotonnes

Note: *Other industrial sectors* include all remaining industrial sectors other than the upstream oil and gas industry. **Source:** Environment Canada, July 2006

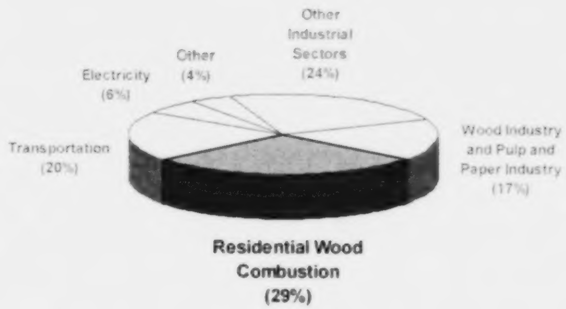
Following on this commitment, the Government of Canada published a Notice of Intent (NOI) in March 2004 that a Federal Agenda on the Reduction of Emissions of Volatile Organic Compounds from Consumer and Commercial Products[17] had been developed. This agenda will help guide the development and implementation of VOC reduction measures, many of which may align with similar efforts in the United States, given the widely shared market between Canada and the U.S. in this sector.

[17] http://www.ec.gc.ca/CEPARegistry/notices/NoticeText.cfm?intNotice=259&intDocument=1686

Residential Wood Combustion

In 2000, residential wood combustion appliances were the second largest source (29%) of direct $PM_{2.5}$ emissions, second only to total emissions from industrial sources (41%).

Primary $PM_{2.5}$ Anthropogenic Emissions, Sector Contributions - 2000
(excludes Open Sources)



Total: 361 kilotonnes

Note: *Other industrial sectors* include all remaining industrial sectors other than the wood industry and the pulp and paper industry. **Source:** Environment Canada, July 2006

Addressing emissions from wood-burning appliances was one of several Joint Initial Actions (JIAs) identified by the CCME under the CWS. Continuing with the work initiated under this JIA, the Government of Canada, in collaboration with other jurisdictions and stakeholders, developed a model municipal bylaw as a tool for municipalities wishing to regulate wood-burning appliances.[18]

Since 2002, the Government of Canada has also been supporting a public education campaign related to residential wood-burning. This campaign encourages the public to adopt best management practices with respect to wood-burning appliances.

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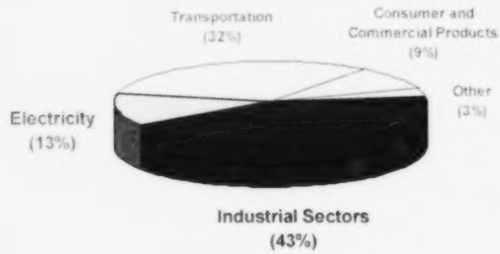
[18] Copies of this model bylaw can be obtained through Environment Canada.

5.3 Industrial Sectors and Electricity Generation

Industrial sectors combined with electricity generation were the largest emitters of aggregated smog-producing emissions in 2000 (56%). The Interim Plan 2001 emphasized the importance of coordinated action by the provinces, territories and federal government in order to reduce the emissions from these sectors effectively.

Primary $PM_{2.5}$, SO_2, NO_X and VOC Aggregated Anthropogenic Emissions, Sector Contributions - 2000
(excludes Open Sources)



Total: 7,290 kilotonnes
Source: Environment Canada, July 2006

> **Industrial Sectors and Electricity Generation**
>
> Major industrial sectors include ***Upstream Oil and Gas*** (including ***Oil Sands***), ***Base Metal Smelting, Wood Products, Pulp and Paper***, ***Petroleum Refining***, and others.
>
> ***Electricity generation*** refers to power plants that produce energy from fuel combustion (e.g. coal, oil and natural gas).

One venue for coordinated action was the development of Multi-pollutant Emission Reduction Strategies (MERS) for key industrial sectors. MERS was one of several Joint Initial Actions (JIAs) identified by the CCME under the CWS. In 2001, the MERS JIA was revisited due to concerns over the need for jurisdictional flexibility in addressing these sectors. As a result, the MERS process was to proceed on three tracks: (1) National Multi-pollutant Analysis reports; (2) information sharing and coordination among jurisdictions; and (3) National Sector Roll-up.

The first activity in the development of MERS was the preparation of Multi-pollutant Emission Reduction Analysis Foundation (MERAF) reports for targeted industrial sectors. MERAF reports were developed in consultation with industry and other stakeholders and were intended to inform and support the development of emission reduction actions. MERAF reports were finalized in 2002 for pulp and paper, lumber and allied wood products, iron and steel, base metals smelting, hot mix asphalt paving, concrete batching, and electric power generation. These reports provide such information as: industry profile; sector emissions (current and projected); domestic and international emission standards; best available pollution prevention and control techniques; possible emission reduction options; and identification of areas for further analysis.

The MERAF reports were a positive step forward. However, jurisdictions were unable to complete the MERS roll-up, which would have provided information regarding the extent to which emissions reductions were being achieved or would have been achieved from each of the MERS sectors. As a result, information sharing and coordination among the jurisdictions to explore options to develop actual Canada-wide emission reduction approaches for these sectors have not taken place.

Another venue for coordinated action was the development under the CCME of a *National Framework for Petroleum Refinery Emission Reductions.*[19] Published in 2005, this framework provides a methodology to both prioritize and set facility-wide emission caps within this sector. Joint collaborative work is also underway with the provinces and industry to address some sources within the upstream oil and gas sector. Results from this work have contributed to the development of a flaring and venting guide for the sector, which has been implemented by the province of Alberta. This has also led to a draft Best Management Practices Guide with the Canadian Association of Petroleum Producers to reduce fugitive emissions.

Perhaps the single most concerted effort in reducing emissions from the industrial sector to date has been the Canadian Acid Rain Program. Although this program was put in place to address acid rain-causing emissions (SO_2 and NO_X), the program also reduces smog and benefits human health because SO_2 and NO_X are both smog-producing pollutants. The program set an initial SO_2 emissions cap of 2.3 million tonnes for the seven eastern-most provinces. This cap expired in 1999; however, emissions in these seven provinces remained 29% below the cap in 2003. Renewed interest in continuing to reduce emissions that cause acid rain led to endorsement by federal, provincial, and territorial Energy and Environment Ministers of *The Canada-wide Acid Rain Strategy for Post 2000*[20] in October 1998.

The main objective of the Canada-wide Acid Rain Strategy for Post-2000 is to meet the environmental threshold of critical loads for acid deposition across Canada over the long term. To achieve this goal, the Strategy called for a number of actions, including the establishment of new SO_2 emission reduction targets in eastern Canada. These targets have been set and were published in the *2001 Annual Progress Report on the Canada-wide Acid Rain Strategy for Post-2000*. Some of the initial targets have been reached. However, acid rain and deposition remain critical issues for Canada. Despite the reductions in acidifying emissions (66% reduction in SO_2 emissions alone since 1980 in eastern Canada), critical loads are still exceeded. In addition, the acidity levels of lakes are not improving and the anticipated recovery of fish and other aquatic biota is not detected, except in the more immediate vicinity of the sources. Further action is needed to solve the persistent acid deposition problem in eastern Canada and prevent one in the west and north.

Under CEPA, the federal government can develop guidelines, codes of practice and pollution prevention planning initiatives to manage emissions from industrial sectors and facilities. Using these tools, the Government of Canada released ***New Source Emission Guidelines for Thermal Electricity Generation***[21] in April 2003. These guidelines contain limits for emissions of sulphur dioxide, nitrogen oxides and particulate matter from new power plants starting commercial operation after April 1, 2003, based on the performance of the best available, economically feasible technologies. The intent of these guidelines is that new power plants and replaced generating units be built clean.

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[19] http://www.ccme.ca/ourwork/air.html?category_id=69#246

[20] http://www.ec.gc.ca/acidrain/strat/strat_e.htm

[21] http://www.ec.gc.ca/CEPARegistry/notices/NoticeText.cfm?intNotice=201&intDocument=1287

In April 2006, the Government of Canada released a *Notice requiring the preparation and implementation of pollution prevention plans in respect of specified toxic substances released from base metals smelters and refineries and zinc plants.*[22] As a result, base metals smelters will be required to prepare and implement comprehensive Pollution Prevention Plans and to publicly report on their conformance with an ***Environmental Code of Practice for Base Metals Smelters and Refineries***. Base metal smelters melt and separate valuable metals from less desirable metals and impurities. As smelters implement the Plans and address emission reduction targets, it is expected that the sector will reduce annual sulphur dioxide emissions by over 600,000 tonnes (about 70%) and will reduce annual particulate matter emissions containing metals by over 3,000 tonnes (about 50%) by 2015 from 1998 levels.

5.4 Continuous Improvement and Keeping Clean Areas Clean

The CWS ambient targets are recognized as an important first step toward the long-term goal of minimizing the risk to health and the environment posed by PM and ozone. There are numerous locations across Canada where ambient levels are currently below the CWS. Actions are required to ensure that levels in these areas do not rise to the CWS, but rather are reduced over time, and that clean areas are kept clean. As such, the CWS contain *Continuous Improvement* (CI) and *Keeping Clean Areas Clean* (KCAC) provisions for guidance on environmental management in areas where ambient $PM_{2.5}$ and ozone levels are below the CWS.

Federal efforts contributing to these goals include all of the actions outlined in Section 5, such as those described for the transportation sector, which apply to all regions of Canada, above or below the CWS. This also applies to other federal initiatives, notably pollution prevention planning, the New Source Emission Guidelines for Thermal Electricity Generation and the Environmental Code of Practice for Base Metals Smelters and Refineries.

The Government of Canada also contributes to CI and KCAC through programs such as the Sustainable Development in Government Operations (SDGO) and Federal House in Order (FHIO) initiatives (see Section 5.5).

Clean areas in Canada include our national parks. Environment Canada and Parks Canada have begun to informally explore options for air quality monitoring in these areas, including a program for visibility monitoring, as visibility is an indicator of growing levels of smog. As part of this work, Environment Canada is collaborating with the U.S. EPA and the U.S. Interagency Monitoring of Protected Visual Environments (IMPROVE, which is responsible for visibility monitoring in U.S. national parks), to evaluate the comparability of IMPROVE and Canadian-equivalent visibility monitoring methods.

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[22] http://www.ec.gc.ca/CEPARegistry/notices/NoticeText.cfm?intNotice=353&intDocument=2357

5.5 Other Supportive Government Actions

As outlined in the Interim Plan 2001, the federal government has undertaken a number of additional supportive measures that contribute to emissions reductions and cleaner air for all Canadians. These include: the greening of operations and encouraging sustainability in all activities of the Government of Canada; addressing emissions from agriculture activities; encouraging innovation and the development of new technologies; and working collaboratively with other jurisdictions, the private sector, and non-governmental organizations. This section provides an outline of some of these supportive measures to achieve cleaner air.

Greening of Government

The Government of Canada is committed to operating in a manner that supports sustainable development.[23] The Sustainable Development in Government Operations (SDGO) initiative supports efforts by the federal government to reduce its emissions of air pollutants in a number of ways: by integrating sustainable development principles in all federal government operations; by coordinating and reporting on the federal government's efforts to green its operations; and by sharing knowledge on sustainable development tools.

In April 2005, the Office of Greening Government Operations (OGGO) was created in Public Works and Government Services Canada to lead and facilitate a government-wide approach to the greening of government operations. OGGO's mandate is to accelerate and provide leadership on the greening of government operations. The office works closely with Environment Canada and the Treasury Board Secretariat and has established interdepartmental steering groups to help set the agenda for government-wide action in key operational areas and to facilitate the sharing of information and develop enabling tools to improve government's environmental performance.

The *Federal House in Order*[24] initiative, which aims to reduce greenhouse gas (GHG) emissions from federal facilities, also helps support smog-reduction efforts, as many sources of GHGs and smog-forming pollutants are the same.

Ontario Region Staff Corporate Smog Action Plan

Building on the success of a pilot project in 2001, a corporate Smog Action Plan was implemented for Environment Canada staff in the Ontario region in 2002. This plan encourages no- or low-emissions options for employee transportation, best practices at home and at the office, and action plans for smog alert days. During smog alert days in 2005, 21 fewer tonnes of pollutants were released to the air by staff of Environment Canada at Downsview (Toronto) as a result of these cleaner air choices.

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[23] http://www.greeninggovernment.gc.ca/default.asp?lang=En&n=9697C298-1

[24] http://www.fhio-ifppe.gc.ca/default.asp?lang=En&n=A78D906F-1

Agriculture Initiatives

Agriculture and Agri-Food Canada[25] (AAFC) is leading initiatives to improve air quality through the Agricultural Policy Framework.[26] Policy options that could enhance the sector's capacity to mitigate impacts on air quality, on the ozone layer, and to address climate change are being evaluated. Education and awareness activities and financial support assist farmers to implement beneficial management practices.

AAFC closely monitors and directly participates in the various initiatives designed to manage agricultural and other sources of air pollutants, such as those under the National Agri-Environmental Standards Initiative, as discussed in Section 5.7.3. AAFC's Research Branch is also working to develop ways to reduce the adverse impact of agricultural practices on air quality. Research and development activities are being conducted to support sustainable farming systems and to increase our understanding of air-related issues and their impact on agriculture.

Innovation and Technology Support

Investments in research, development and implementation of cleaner technologies do not necessarily result in short-term emission reductions, though these efforts are nevertheless important to ensure a cleaner, more sustainable future. Programs supported by the federal government include:

Sustainable Development Technology Canada.[27] This is a not-for-profit foundation that finances and supports the development and demonstration of clean technologies related to climate change, clean air, water quality and soil.

The Program of Energy Research and Development.[28] This is a program operated by Natural Resources Canada that promotes the development of energy-efficient, renewable, and alternative energy sources and technologies. Examples of research supported by this program include work on clean coal combustion, transportation sources, and upstream oil and gas issues.

[25] http://www.agr.gc.ca/acaaf/index_e.html

[26] http://www.agr.gc.ca/puttingcanadafirst/index_e.php

[27] http://www.sdtc.ca/

[28] http://www2.nrcan.gc.ca/es/oerd/english/View.asp

Natural Resources Canada's (NRCan) Sustainable Development Strategy.[29] Among other actions, this strategy supports efforts to accelerate the development and use of emerging renewable energy technologies in Canada aimed at reducing the environmental footprint of energy production and end use. NRCan and Environment Canada are working together with a range of stakeholders to develop and deploy innovative, cleaner energy technologies. For example, the federal government has implemented several economic measures to promote development, installation and technological advances within the renewable energy field. Recent investments include the *Wind Power Production Incentive*[30] and funding to develop a *Sustainable Energy Science and Technology Strategy.*[31] The combination of these measures helped wind energy grow by 35% between 2000 and 2004. In 2005, the amount of wind energy deployed in Canada (approximately 240 megawatts, MW) surpassed the previous record of 122 MW set in 2004.

Green Municipal Fund.[32] The Green Municipal Fund (GMF) is financially sponsored by the Government of Canada in collaboration with the Federation of Canadian Municipalities to stimulate environmental projects by municipal governments and their partners that generate measurable environmental, economic and social benefits. The fund supports a range of activities leading up to and including the physical implementation of environmental infrastructure projects.

5.6 Efforts to Reduce Transboundary Sources of Air Pollution

The Interim Plan 2001 underscored the importance of international cooperation for clean air. Cooperation with the United States is particularly important, given that in some regions of eastern Canada, between 30% and 90% of smog comes from the U.S. under southerly airflows. Specific actions identified in the Interim Plan 2001 included the implementation of the Ozone Annex to the Canada–United States Air Quality Agreement, and consideration of further work under the agreement, including whether and how to address bilateral issues related to particulate matter.

This section provides an overview of U.S. commitments under the Ozone Annex, and related air quality efforts.

The Canada–U.S. Air Quality Agreement

The Canada–U.S. Air Quality Agreement (AQA) was signed in 1991 to address the transboundary transport of acidifying emissions of SO_2 and NO_X in both countries. Both countries committed to reduce emissions of these pollutants under the terms of the Acid Rain Annex to the agreement. Measures contained in this annex to reduce NO_X emissions from stationary sources, diesel and gasoline-powered vehicles will contribute to reductions in acid deposition, ozone, nitrate particles and vapours.

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[29] http://www.nrcan-rncan.gc.ca/sd-dd/pubs/strat2004/english/min_e.html

[30] http://www.canren.gc.ca/programs/index.asp?CaId=107&PgId=622

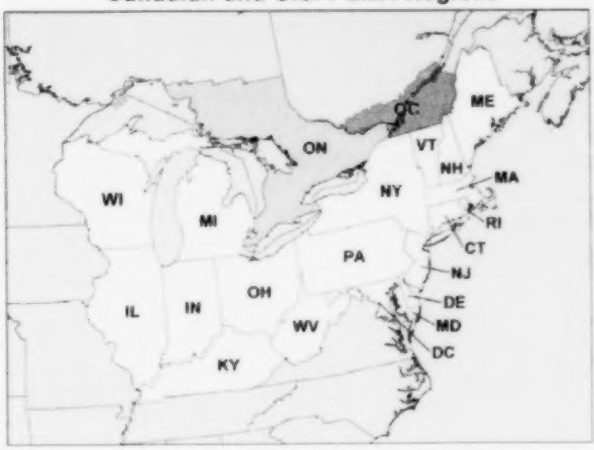
[31] http://www.nrcan-rncan.gc.ca/media/newsreleases/2005/200530a_e.htm

[32] http://www.sustainablecommunities.fcm.ca/GMF/

In December 2000, the AQA was expanded with the addition of an Ozone Annex to address transboundary ground-level ozone. The Ozone Annex commits Canada and the U.S. to reduce emissions of NO_X and VOC, the two main precursors of ozone, in the region of each country from which these transboundary flows originate.

The annex defines a transboundary region in each country, known as the Pollutant Emission Management Area (PEMA). The states and provinces within that region are those areas where emission reductions are most important for transboundary ozone. In the United States, the region covers 18 states and the District of Columbia (approximately 40% of the U.S. population). In Canada, the region includes central and southern Ontario and southern Quebec (more than 50% of Canada's population).

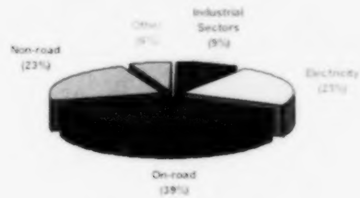
Canadian and U.S. PEMA Regions



The key commitments for the United States under the Ozone Annex include:[33]

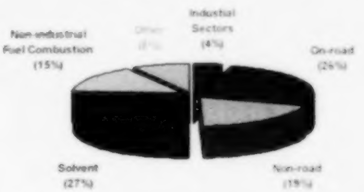
- implementation of the NO_X transport emission reductions program, known as the NO_X SIP (State Implementation Plan) Call, in the PEMA states that are subject to the rule;
- implementation of existing U.S. vehicle, non-road engine, and fuel quality rules to achieve both VOC and NO_X reductions;
- implementation of existing U.S. rules for control of emissions from stationary sources of hazardous air pollutants and control of VOC from consumer and commercial products, architectural coatings, and automobile repair; and
- implementation of 36 existing U.S. new source performance standards, to achieve VOC and NO_X reductions from new sources.

NO_X U.S. PEMA Anthropogenic Emissions, Sector Contributions - 2004
(excludes Forest Fires and Biogenic Emissions)



Total: 6,043 kilotonnes

VOC U.S. PEMA Anthropogenic Emissions, Sector Contributions - 2004
(excludes Forest Fires and Biogenic Emissions)



Total: 5,186 kilotonnes

Source: EPA

[33] The U.S. non-road sector is equivalent to the Canadian combined emissions from the off-road sector, marine vessels, aviation and rail.

The annex also contains provisions for both countries to include in their biennial progress reports information on the following: all anthropogenic NO_x and all anthropogenic and biogenic VOC emissions within the PEMA; ambient air quality information on all relevant monitors located within 500 km of the border; and information on implementation of the controls agreed to under the annex.

Anticipated U.S. Emission Reductions

Implementation of the Ozone Annex commitments, together with anticipated national and area-specific reductions, are estimated to reduce annual NO_x emissions in the U.S. PEMA by 51% from 1990 levels and to reduce annual VOC emissions by 49% from 1990 levels by 2010.

Canadian and U.S. scientists conducted joint studies to evaluate the transboundary transport potential of PM and its precursors. These discussions and studies resulted in the production of a report entitled *Canada–United States Transboundary PM Science Assessment*[34] (2004). This report helps build the science base needed to inform any future discussions between Canada and the U.S. on potential additional emission reductions of PM and its precursors.

The Clean Air Interstate Rule

In 2005, the U.S. finalized its Clean Air Interstate Rule (CAIR), which focuses on states whose power plant emissions are significantly contributing to fine particle and ozone pollution in downwind states in the eastern U.S. CAIR requires 28 states in the eastern half of the nation and the District of Columbia (including 14 of the 18 PEMA states plus DC) to reduce emissions of SO_2 and/or NO_x. Cap and trade programs associated with CAIR will reduce SO_2 emissions from power plants by 4 million U.S. tons (3.6 megatonnes, Mt) in 2010 and by 5.1 million tons (4.6 Mt) in 2015, and will reduce annual NO_x emissions by 1.4 million tons (1.3 Mt) in 2009 and by 1.6 million tons (1.5 Mt) in 2015.

5.7 Monitoring and Science

Monitoring and science form the basis of our knowledge of air issues, including: ambient levels of pollutants; how these pollutants interact in the air; how they move across political boundaries; what their sources are; and their effects on health and the environment. This information can then be used to inform regulations and policies, and to inform the public of both air quality-related risks and actions that they can take to reduce impacts on their health and the environment.

The Government of Canada plays a leadership role in researching, measuring and monitoring air quality and its impact on human health and the environment. The Interim Plan 2001 outlined a series of actions the federal government committed to take in support of the CWS, including new initiatives related to science and monitoring, forecasting, and health research.

This section provides an outline of the work conducted by the federal government from 2000 to 2005, both independently and in collaboration with others.

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[34] http://www.msc-smc.ec.gc.ca/saib/smog/transboundary/transboundary_e.pdf

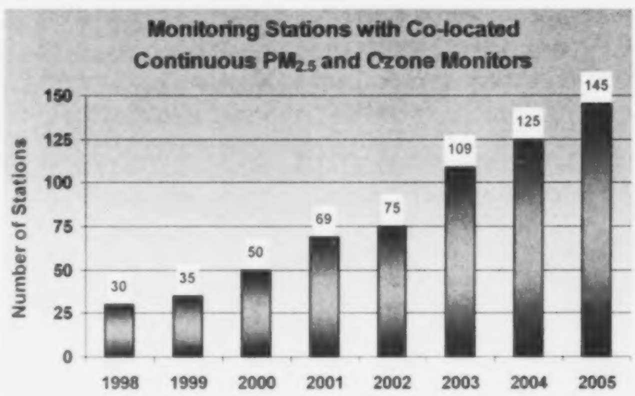
5.7.1 Ambient Monitoring

Air quality monitoring measures the level of pollutants present in the air. This information is then used for a variety of purposes, including evaluation of the effectiveness of emission reduction measures, trends, notification of smog advisories, health studies and comparison with standards.

The National Air Pollution Surveillance (NAPS) Network and the Canadian Air and Precipitation Monitoring Network (CAPMoN) are the two major routine monitoring networks in Canada. NAPS is a joint federal, provincial, territorial and municipal partnership program, and CAPMoN is operated by Environment Canada. Established in 1969 as an ad hoc partnership, NAPS has since then progressed to a formal partnership following the endorsement of a Memorandum of Understanding (MOU) between federal, provincial, territorial and municipal monitoring agencies in 2004. This agreement codifies the long-term partnership that has existed since 1969.

As part of the NAPS MOU, the Canada-wide Air Quality Database was defined for storage of data collected by both the NAPS and CAPMoN networks. More recently, this database has been upgraded to allow web-based tools for the visualization of monitoring stations and to generate summaries of air quality information.[35]

CAPMoN consists of 28 stations located in rural or remote areas, including one station in the United States. Since CAPMoN stations are typically not in the vicinity of local sources of air pollution, they are key to understanding trends in pollutant levels from a regional perspective. They also make an important contribution to monitoring clean areas.



Since 2000, the federal government has invested $14 million into NAPS and CAPMoN for equipment upgrades and establishment of new stations. The NAPS network now comprises 260 monitoring stations (189 in urban locations and 71 in rural locations) located in 172 communities/areas across Canada. The number of stations monitoring both $PM_{2.5}$ and ozone has increased nearly threefold to 145 since the CWS was signed in 2000. All communities in Canada with a population greater than 100,000 can now effectively report on ambient $PM_{2.5}$ and ozone.

[35] http://www.etc-cte.ec.gc.ca/napsstations/Default.aspx

Targeted emission reduction actions are aided by knowledge of the chemical composition of the particulate mass. Health research is also increasingly pointing to the need to identify the chemical species that may be causing the health effects associated with PM. To increase our understanding of the substances contributing to the PM mass and associated health effects, additional federal funding has allowed the establishment of a national PM chemical speciation network consisting of 17 stations (12 NAPS, 5 CAPMoN). Resources have also been allocated for the deployment of a national PM methods-comparison network, the results of which will assist in defining monitoring methods and approaches to use for evaluating the achievement of the CWS.

CRUISER

Special monitoring studies are conducted by the *Canadian Regional and Urban Investigation System for Environmental Research (CRUISER)*, an advanced mobile air quality lab developed by Environment Canada's Air Quality Research Division (AQRD). *RASCAL* (*Rapid Acquisition SCanning Aerosol Lidar*, also developed by AQRD), and CRUISER together provide a unique capacity to collect information on pollutants in the air at fixed locations and while moving from place to place. To date, fixed measurements have been obtained in several locations across Canada, including Windsor and Toronto in Ontario, and North Vancouver, Golden, and Kelowna in British Columbia. Mobile measurements have been obtained on the streets of Windsor, Toronto, the Lower Fraser Valley, Golden and several other locations. The results of these studies have been discussed at several public symposiums hosted by organizations such as the BC Lung Association, Golden town council and the Health Effects Institute.

5.7.2 Emissions Inventory Compilation and Reporting

Emissions inventories provide an assessment of the relative contribution of various anthropogenic and natural sources of emissions for different time periods. The comprehensive emissions inventories are compiled by Environment Canada in collaboration with the provinces and territories. These inventories consider more than 60 industrial and non-industrial categories of emissions of air pollutants known as the Criteria Air Contaminants (CAC), which include sulphur oxides, nitrogen oxides, volatile organic compounds, primary particulate matter (in three size fractions), ammonia and carbon monoxide. The emissions information can be summarized at the national, provincial, territorial and municipal levels, and used to inform decision making for air quality management. It is also used in air quality modelling.

Significant strides have been made over the past five years in strengthening the national collection of emissions data and the development of emissions inventories. This section outlines efforts by the federal government in this area. Emissions data for Canada and the U.S. are provided in Section 6.

The Emissions and Projections Working Group

The Emissions and Projections Working Group (EPWG) is a cooperative federal, provincial, territorial and municipal ad hoc working group chaired by Environment Canada. Group members collaborate in the development of *National Comprehensive Emissions Inventories* at the national, provincial and territorial levels, and assist in the development of emissions projections for future years. The latest available emissions inventory is for the year 2002. The 2005 emissions inventory is currently being compiled and is not yet available.

As methodologies for compiling and collecting emissions information improve over time, the EPWG also produces updates to past emissions inventories based on more recent methodologies to ensure comparability of past and current information.

National Pollutant Release Inventory

The National Pollutant Release Inventory[36] (NPRI) is legally mandated under CEPA to collect, and make public, information on releases of over 300 pollutants from industrial and commercial facilities across Canada for each calendar year. Companies that emit, manufacture, process or otherwise use a listed[37] substance at or above the reporting threshold for the substance must report their releases or transfers to Environment Canada annually. NPRI data form a fundamental component for the development of the anthropogenic component of emission inventories in Canada.

As part of federal commitments under the Interim Plan 2001, the list of substances that facilities must report to the NPRI was expanded and now includes SO_2, NO_X, PM, carbon monoxide and VOC.

NPRI data are publicly available and searchable by location or substance. In 2004, public access to this information was improved with the introduction of the NPRI Communities Portal,[38] which provides emissions information at the community level.

NPRI Communities Portal

Launched at Globe 2004, the NPRI Communities Portal continues to be a starting point for Canadians for finding information about industrial pollution in their communities. The portal includes some health and environmental information, a comprehensive search engine, and a GIS mapping application. This mapping application allows users to view reporting facilities in selected locations or communities, as well as the amount of pollutants released by those facilities.

[36] http://www.ec.gc.ca/pdb/npri/npri_home_e.cfm

[37] http://www.ec.gc.ca/pdb/npri/2005Guidance/Substance_list2005_e.cfm

[38] http://gis.ec.gc.ca/npri/root/main/main.asp?Lan=en

5.7.3 Environmental and Health Science

The Government of Canada, principally through Environment Canada and Health Canada, plays a strong leadership role in conducting environmental and health-related research. This section highlights some of the major work that has been conducted by the federal government both alone and in collaboration with others from 2000 to 2005.

Advancements in Environmental Science

Over the past five years, Environment Canada has led the development of a number of science assessments, conducted intensive field studies, and developed and applied a state-of-the-art air quality model. Below are highlights of advancements in environmental science.

Prairie 2005 (Edmonton) and Pacific 2001 (Lower Fraser Valley). Intensive field studies designed to better understand contributions to ozone from local and transboundary sources and to validate air quality models.

The Canada–United States Transboundary PM Science Assessment[39] (2004). Work detailing the state of science and knowledge from a transboundary perspective between Canada and the United States.

The 2004 Canadian Acid Deposition Science Assessment.[40] A collaborative effort coordinated by Environment Canada that reviewed current science and monitoring information on acid deposition and its effects in Canada.

International Consortium for Atmospheric Research on Transport and Transformation (ICARTT)[41] (2004). Intensive field study by Canadian, American and European institutions to gain a better understanding of the transport and transformation of air pollutants in regions of the North Atlantic.

Atmospheric Science of Particulate Matter: Update in Support of the Canada-wide Standards for Particulate Matter and Ozone[42] (2003). Provided primary material used for the 2005 review of the PM and Ozone CWS.

Atmospheric Science of Ground-Level Ozone: Update in Support of the Canada-wide Standards for Particulate Matter and Ozone[43] (2003). Provided primary material used for the 2005 review of the PM and Ozone CWS.

Particulate Matter Science for Policy Makers, A NARSTO Assessment[44] (2003). Work outlining the current understanding of PM within the North American context.

Precursor Contributions to Ambient Fine Particulate Matter in Canada[45] (2001). Captured the state of knowledge on the contributions of precursor gases to secondary PM formation in Canada.

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[39] http://www.msc-smc.ec.gc.ca/saib/smog/transboundary/transboundary_e.pdf

[40] http://www.msc-smc.ec.gc.ca/saib/acid/acid_e.html

[41] http://esrl.noaa.gov/csd/ICARTT/

[42] http://www.ccme.ca/assets/pdf/scrvw_pm_atmsphrc_scnc_e.pdf

[43] http://www.ccme.ca/assets/pdf/scrvw_oz_atmsphrc_sc_e.pdf

[44] http://www.narsto.com/

[45] http://www.msc-smc.ec.gc.ca/saib/smog/docs/PRECURSOR_e.PDF

The National Agri-Environmental Standards Initiative (NAESI)[46] – In progress. NAESI is a collaborative partnership between Agriculture and Agri-Food Canada (AAFC) and Environment Canada. Significant research and development activities are underway to address the scientific gaps to enable the production of scientifically based standards for the agriculture sector, against which environmental performance can be measured for ammonia (particulate matter) and odour.

A Unified Regional Air Quality Modelling System (AURAMS). AURAMS is a state-of-the-art atmospheric modelling system developed by Environment Canada scientists. AURAMS is capable of simultaneously modelling PM, ozone and acid deposition over the entire North American continent, and on seasonal and annual time-scales. AURAMS is easily connected to health effect and economic valuation models, and it is used for evaluating existing and projected emission reduction commitments as well as emission scenarios to inform policy decisions.

Advances in Health Sciences

Health Canada was the leading agency in the development of health information documents used for the 2003 review of the CWS. In addition to this work, it has conducted a range of studies as part of broader national and international scientific efforts. Below is an abbreviated list of some of the work conducted from 2000 to 2005.

Estimated Number of Excess Deaths in Canada Due to Air Pollution.[47] A study released in 2004 that estimated the number of excess deaths due to air pollution in eight major Canadian cities. The study found that air pollution in these eight cities is associated with 5,900 excess deaths per year at current (1998-2000) air pollutant levels.

Toxic Substances Research Initiative (TSRI). This work included studies examining population health effects of major urban air pollutants, with emphasis on the conditions that elicited changes to mortality and hospital admission signals in administrative databases. The work also examined the toxicological basis for PM and ozone health effects, specific cardiac signals and disease associated with ambient air pollution, and sources and characteristics of major smog components.

[46] http://www.agr.gc.ca/env/naesi_e.php

[47] http://www.hc-sc.gc.ca/ahc-asc/media/nr-cp/2005/2005_32bk2_e.html

The Border Air Quality Strategy (BAQS). In partnership with the United States and others, Health Canada has facilitated work in the Georgia Basin–Puget Sound region and in Southwestern Ontario under the Canada–U.S. BAQS. Some of the work conducted under the strategy includes:

Windsor 23,000 Children Survey, which gathered baseline information on children's respiratory health status for lung function, inflammation and asthma.

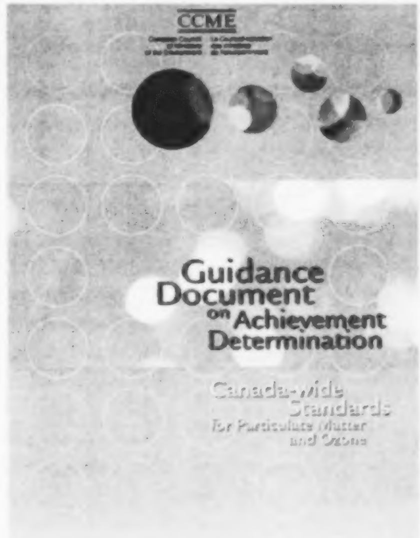
The Windsor Exposure Assessment Study, which examined the spatial variability of air pollution exposure as well as personal exposure. These exposure studies were designed to match the U.S. EPA exposure study in Detroit (DEARS).

The Georgia Basin–Puget Sound Studies, which examined the relationships between air pollution and adverse respiratory outcomes in children; between maternal exposure and birth outcomes; birth outcomes and exposure to wood smoke and traffic; and the effect on cardiovascular disease. These studies were coordinated through the British Columbia Centre for Disease Control, and carried out by the University of British Columbia, the University of Victoria and the University of Washington.

In addition to research and other projects, Health Canada continues to conduct risk assessments of major smog pollutants with emphasis on PM and ozone. Due to the rapid pace and voluminous nature of research on these two substances, an impressively large new body of evidence is available and requires ongoing review. Relatively recent reviews by other jurisdictions (U.S. EPA, WHO) buttress the view that both PM and ozone exert public health impacts, and that these impacts are apparent over the range of concentrations experienced in North America. Ongoing review will examine the broad conclusions that can be drawn from the newest literature, but will also attempt to focus on issues most relevant to risk management.

5.7.4 Advances in Methodologies and Procedures on Reporting

This section provides an overview of some of the work undertaken by Environment Canada in collaboration with other jurisdictions to help advance methodologies and procedures related to CWS reporting.



The CWS agreement called for the production of two documents: a *Guidance Document on Achievement Determination* (GDAD) and a *Monitoring Protocol*. Environment Canada took a lead role in the production of these documents, by acting as co-chair of related working groups, providing administrative support and organizing stakeholder workshops.

The GDAD was completed in September 2002 and is currently being revised. The completion of the *Monitoring Protocol* is pending following a decision to first address PM monitoring inter-comparison.[48]

The GDAD is key to the CWS process as it contains the procedures and methodologies to be used when evaluating whether the CWS have been achieved. By providing guidance on how to establish CWS reporting areas, where to site PM and ozone CWS monitoring stations, and data treatment and analysis procedures, the GDAD ensures comparability and consistency of data across Canada for the purpose of reporting on the CWS.

To gain experience with the application of the GDAD, and to explore where refinements may be needed in advance of the 2010 achievement date, four pilot projects have been conducted on different provisions of the GDAD. These pilot projects were led by Environment Canada and conducted in collaboration with jurisdictions. Lessons learned from these pilot projects were shared during two stakeholder workshops, and the ensuing recommendations are being incorporated into the revised GDAD.

[48] For more on this, refer to the Appendix of the report *Fine Particles and Ozone in Canada, A Canada-wide Standards Perspective, 2003 National Summary*, available at: http://www.ccme.ca/assets/pdf/2003_pm_oz_ntnlsmryrpt_e.pdf

The reports produced by these four pilot projects are listed below, with copies available from Environment Canada and the participating jurisdictions.

- Alberta pilot project: *Alberta Demonstration Project for the CASA PM and Ozone Project Team*, October 2003.
- Quebec pilot project: *Preliminary Application and Evaluation of Selected Provisions of the Guidance Document on Achievement Determination for the $PM_{2.5}$ and Ozone Canada-wide Standards*, June 25, 2003.
- Ontario pilot project: *Preliminary Application and Evaluation of the Provisions of the Guidance Document on Achievement Determination for the $PM_{2.5}$ and Ozone Canada-wide Standards*, 2005.
- Atlantic Canada pilot project: *Assessment of Atlantic Canada Ambient Monitoring Sites for Canada-wide Standards Reporting*, March 2004; *Basecase and Atlantic Provinces Modelling Scenarios*, April 2004; and *Atlantic CWS GDAD Determination*, April 2005.

Environment Canada, in collaboration with other jurisdictions, also led to the production of a Guidance Document on Continuous Improvement and Keeping Clean Areas Clean,[49] and the production of three annual National Summaries on fine particles and ozone (all three available at www.ccme.ca).

5.7.5 Public Outreach and Engagement

As noted in the Interim Plan 2001, the Government of Canada plays a key role in ensuring that Canadians are well-informed and can take action to both reduce their emissions of air pollutants and to protect their health. A variety of education and outreach programs are in place that provide Canadians with valuable tools, information and opportunity for engagement. These include:

Clean Air Day. Held annually on the Wednesday of Canadian Environment Week, Clean Air Day was proclaimed by the Government of Canada to increase public awareness and action on clean air.

Clean Air Day Sustainable Transportation Awareness Campaign. Delivered in partnership with the Canadian Urban Transit Association in 65 communities throughout Canada, this campaign encourages transportation alternatives to the single-occupant vehicle.

Clean Air Online (CAOL). CAOL is Environment Canada's comprehensive website on air pollution and associated issues such as greenhouse gas emissions, climate change and stratospheric ozone depletion. CAOL also provides resources that support individual and community actions to reduce emissions. http://www.ec.gc.ca/cleanair-airpur/

Transportation Outreach Programs. A number of programs exist to assist in making transportation more sustainable. Employers and communities can take advantage of these programs, which encourage workers and citizens to ensure that their transportation choices help reduce air pollution.

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[49] In draft at time of printing.

The Environmental Choice Program. Environment Canada's ecolabelling program and its EcoLogo^M symbol help consumers identify products and services that are less harmful to the environment. The goal of the program is to encourage the supply of more sustainable products and services and to help consumers buy "green."

Canadian Environment Awards. In partnership with Canadian Geographic Magazine and with the support of private sector sponsors, these awards celebrate groups, local enterprises and individuals that have made a significant contribution to preserving or renewing the environment.

The Environment and Sustainable Development Indicators (ESDI) Initiative.[50] This initiative was proposed by the National Round Table on the Environment and the Economy (NRTEE) to provide simple indicators for tracking the state of Canada's natural capital assets. In response to this proposal, the Government of Canada published the *Canadian Environmental Sustainability Indicators*[51] report in 2005, which includes an air quality indicator.

Air Quality Forecasts. Air quality forecasts provide Canadians with information on future air quality conditions. With this information, Canadians can take preventative actions to reduce activities that contribute to smog, and to better protect their health and the health of those under their care. The public now has access to 48-hour forecasts for all of Canada.[52] Advance smog advisories[53] are also issued in collaboration with provincial partners.

[50] http://www.nrtee-trnee.ca/Publications/HTML/Complete-Documents/Report_Indicators_E/ESDI-Report_IntroPage_E.htm

[51] http://www.statcan.ca/english/freepub/16-251-XIE/16-251-XIE2006000.pdf

[52] http://www.msc-smc.ec.gc.ca/aq_smog/chronos_e.cfm

[53] http://www.msc-smc.ec.gc.ca/aq_smog/aqforecasts_e.cfm

Summary of Section 5

The federal government has undertaken a number of actions and measures pursuant to the Interim Plan 2001 and its 2003 Progress Report. These measures reflected a combination of approaches, including regulations, voluntary programs and policies, and investments in science, monitoring, and technology innovation.

With transportation being the largest contributor to total anthropogenic NO_X and VOC emissions in Canada, the federal government announced in 2001 a comprehensive agenda to address emissions from the transportation sector, including alignment of our regulations with those in the United States. These regulations will result in ongoing reductions in NO_X, VOC and SO_2 emissions over the next decade.

For industrial sectors and electricity generation, most of the actions taken by the federal government have focused on cooperative efforts with jurisdictions and non-regulatory initiatives such as guidelines, codes of practice and foundation analyses.

Pollution prevention planning, new source guidelines and federal regulations with nationwide application all contribute to the CWS goals of continuous improvement and keeping clean areas clean across Canada.

In recognition of the significance of consumer and commercial products as sources of VOC, the Government of Canada committed to develop a federal action plan to reduce VOC emissions from these products. The federal government also worked with other jurisdictions to jointly develop a model municipal bylaw to reduce emissions from residential wood-burning appliances, one of the largest sources of primary $PM_{2.5}$ in Canada.

Other actions taken by the federal government in support of the CWS include efforts to "green" its operations, through such programs as the Sustainable Development in Government Operations initiative and the Federal House in Order program. The federal government also supports a range of partnership programs, including public outreach efforts with other jurisdictions and partners across the country.

For jurisdictions impacted by transboundary air pollution from the United States, achieving the CWS will depend in part on reductions of this transboundary contribution. Considerable progress has been made in reducing emissions from U.S. source regions under the Canada–U.S. Air Quality Agreement, underscoring the effectiveness of this agreement for addressing transboundary air issues.

The Government of Canada plays a key role in monitoring as well as in health and environmental science. Significant progress has been made over the past five years in strengthening ambient air quality monitoring, emissions reporting and scientific research in support of national air quality efforts.

Efforts by the federal government to encourage innovation and the development of new technologies can also contribute to achievement of the CWS. Technology development programs contributing to clean air goals include efforts led by *Sustainable Development Technology Canada* and Natural Resources Canada's *Program of Energy Research and Development*. Economic measures to promote advances in the renewable energy field also help advance air quality in Canada.

6. EMISSIONS TRENDS AND PROJECTIONS

This section presents emissions information from anthropogenic (human-caused) sources for both Canada and the United States. Although emissions inventories are compiled for both anthropogenic and natural sources (such as vegetation and forest fires), the emission information presented in this section only includes anthropogenic sources. Natural sources, however, can release significant quantities of smog-producing pollutants.

> **Source of Emissions Data**
>
> Canadian emissions inventories are compiled through the federal, provincial and territorial Emissions and Projections Working Group (EPWG), which is chaired by Environment Canada. All Canadian emissions data presented in this section were provided by Environment Canada. The emissions information from the U.S. was obtained from the EPA.

Another broad category of sources which are, for the most part, also not included here, are *Open Sources*. These were not considered because of the generally larger uncertainties associated with their emissions estimates. The only emissions from open sources which are included are those for ammonia (gaseous) since, depending on location, ammonia emissions contribute to PM mass. Open sources refer to a range of emissions that are too dispersed to be captured or released by stacks, chimneys, vents or tailpipes. Instead, these pollutants are emitted to the *open* air, typically over a large area. These sources include emissions of dust from paved and unpaved roads, agricultural operations, mining, construction and demolition activities, and landfills.

It should be noted that percentages in pie charts in this document may not add up exactly to 100, due to rounding errors.

6.1 Sector Contributions to 2002 Smog-producing Emissions

This section presents information on the contributions from major Canadian source-sectors to the national total aggregated emissions of $PM_{2.5}$, SO_2, NO_X and VOC. Also included are the contributions to each of these four pollutants individually as well as for ammonia (NH_3), based on the most recently available emissions inventory (2002).

6.1.1 Aggregated Emissions

Figure 15 presents the contribution of major source-sectors to the national total aggregated emissions of primary $PM_{2.5}$, SO_2, NO_X and VOC from anthropogenic sources. The aggregated emissions of the four pollutants are used only to provide a broad indication of the contribution from major sectors to the collective emissions. The actual contribution of a specific pollutant to ambient $PM_{2.5}$ and ozone will vary by location, time of year and prevailing meteorological conditions.

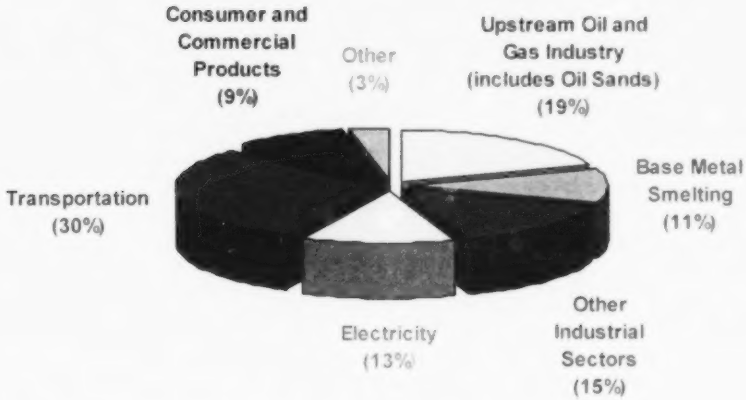
In 2002, the combined emissions from industrial sectors (Figure 15) were the largest contributor to the aggregated emissions, accounting for 45% of the total, with 19% coming from the upstream oil and gas industry (including oil sands), 11% from base metal smelting and the remaining 15% from all *other* industries. Emissions from the transportation sector were the second largest contributor at 30%, followed by electricity generation at 13%, and consumer and commercial products at 9%.

> ***Industrial sectors*** and ***electricity generation*** contributed the most to the national total aggregated emissions (58%) followed by the ***transportation sector*** (30%).

Figure 15: Sector contributions to the national aggregated emissions of four smog-producing pollutants, 2002

Primary $PM_{2.5}$, SO_2, NO_X, and VOC Aggregated Anthropogenic Emissions, Sector Contributions - 2002

(excludes Open Sources)

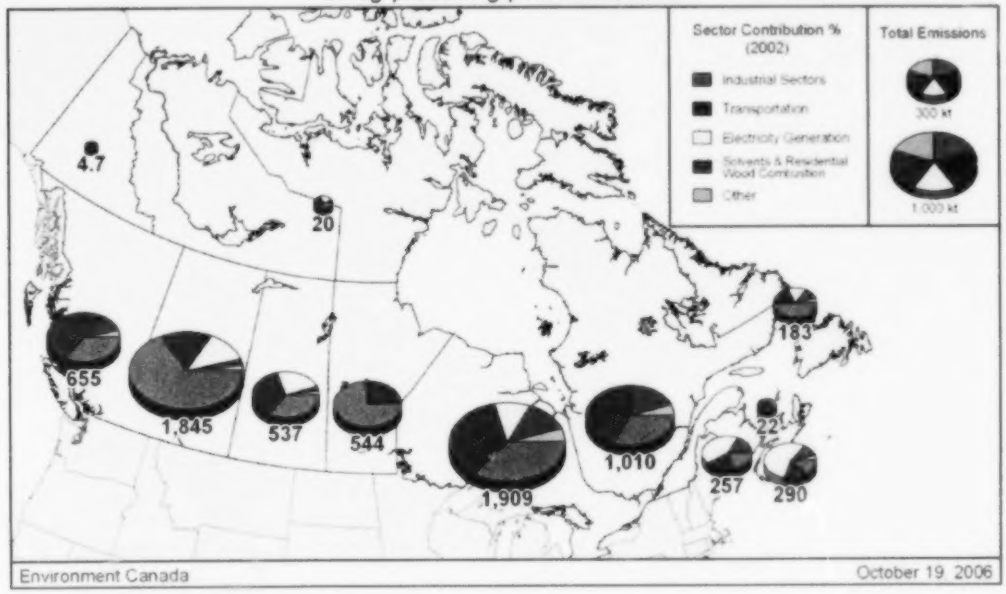


Total: 7,276 kilotonnes

Note: *Other industrial sectors* include all remaining industrial sectors other than base metal smelting and the upstream oil and gas industry. **Source:** Environment Canada, July 2006.

Regionally (Figure 16), there were large differences in these sector contributions. The largest contributors were the industrial sectors for Alberta, Manitoba, and Newfoundland and Labrador, and the transportation sector for British Columbia, Prince Edward Island, Quebec, the Northwest Territories (including Nunavut) and Yukon. In New Brunswick and Nova Scotia, electricity generation was the largest contributor. For Ontario and Saskatchewan, industrial sectors and transportation had similar contributions. Solvents and residential wood combustion were also major contributors in Ontario and Quebec.

Figure 16: Sector contributions to the regional aggregated emissions of four smog-producing pollutants, 2002



Based on aggregated anthropogenic (excludes open sources) emissions of primary $PM_{2.5}$, SO_2, NO_x and VOC

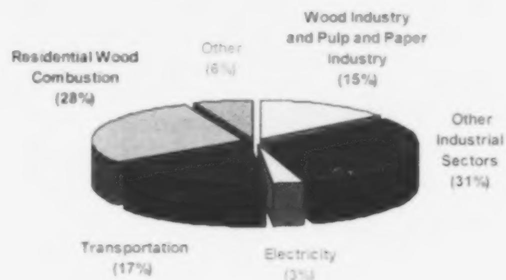
6.1.2 Individual Pollutants

This section presents the contribution of major source-sectors to the national total anthropogenic emissions of five smog-producing pollutants (primary $PM_{2.5}$, SO_2, NO_X, VOC and NH_3) based on the 2002 CAC emissions inventory.

Primary $PM_{2.5}$

The combined emissions from industry were the largest contributor to national emissions of primary $PM_{2.5}$, accounting for 46% of the total. This consisted of 15% from the wood industry and the pulp and paper industry, and 31% from *other* industries. Other large contributors included residential wood combustion (e.g. woodstoves, fireplaces) at 28%, the transportation sector at 7%, and electricity generation at 3%.

Primary $PM_{2.5}$ Anthropogenic Emissions, Sector Contributions - 2002
(excludes Open Sources)



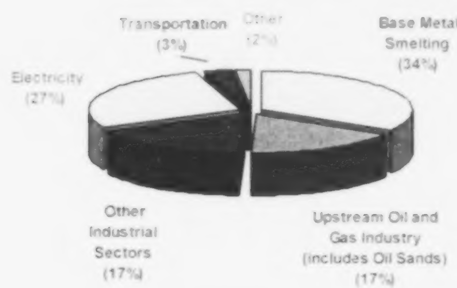
Total: 391 kilotonnes

Note: *Other industrial sectors* include all remaining industrial sectors other than the wood industry and the pulp and paper industry. **Source:** Environment Canada, July 2006

Sulphur Dioxide (SO_2)

The combined emissions from industry accounted for 68% of total national emissions of SO_2. This consisted of 34% from the base metal industry, 17% from upstream oil and gas (includes oil sands) and 17% from all other industries. Electricity generation accounted for 27% of the total, and transportation another 3%.

SO_2 Anthropogenic Emissions, Sector Contributions - 2002
(excludes Open Sources)



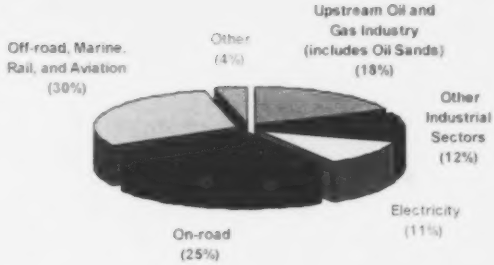
Total: 2,267 kilotonnes

Note: *Other industrial sectors* include all remaining industrial sectors other than base metal smelting and the upstream oil and gas industry. **Source:** Environment Canada, July 2006

Nitrogen Oxides (NO_X)

The transportation sector contributed more than half (55%) of national NO_X emissions, with 25% coming from on-road vehicles, and 30% coming from off-road vehicles and engines, marine, rail, and aviation. Other significant sectors included upstream oil and gas (includes oil sands) at 18% and electricity generation at 11%.

NO_X Anthropogenic Emissions, Sector Contributions - 2002
(excludes Open Sources)



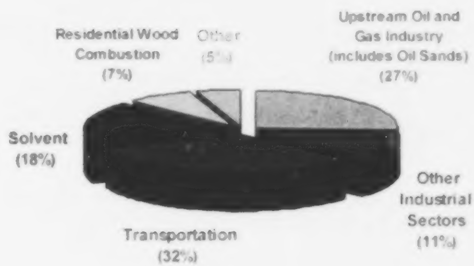
Total: 2,469 kilotonnes

Note: *Other industrial sectors* include all remaining industrial sectors other than the upstream oil and gas industry. **Source:** Environment Canada, July 2006

Volatile Organic Compounds (VOC)

The transportation sector was also the largest contributor to national VOC emissions at 32% of the total. Upstream oil and gas (includes oil sands) was the second largest at 27%, followed by solvent use at 18% and residential wood combustion at 7%.

VOC Anthropogenic Emissions, Sector Contributions - 2002
(excludes Open Sources)



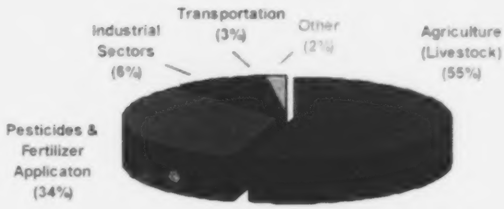
Total: 2,149 kilotonnes

Note: *Other industrial sectors* include all remaining industrial sectors other than the upstream oil and gas industry. **Source:** Environment Canada, July 2006

Ammonia (NH_3)

The emissions from agriculture (livestock) accounted for 55% of total national ammonia emissions, and pesticides and fertilizer applications accounted for another 34%. Other sources included industry at 6% and transportation at 3%.

NH_3 Anthropogenic Emissions, Sector Contributions - 2002
(includes Open Sources other than Forest Fires)



Total: 567 kilotonnes
Source: Environment Canada, July 2006

6.2 Trends and Projections in Emissions

This section indicates how the anthropogenic emissions of some smog-producing pollutants have changed over time (emission trends) and how they are projected to change over the coming years out to 2015 (emissions projections). The trends information is from the Canadian Comprehensive Emissions Inventories. These inventories were compiled for specific years only (and now produced annually) through the federal, provincial and territorial Emissions and Projections Working Group (EPWG) chaired by Environment Canada (see Section 5.7.2). The 1990 and 1995 inventories have been updated to be consistent and comparable with the recently completed 2000 and 2002 inventories.

The emissions projections are based on the *Canadian Criteria Air Contaminants (CAC) Emissions Outlook*, which is a "business/policy as usual" projection. This means that all current energy, environment and related policies in place as of December 2005 were taken into account for the projection period. The impacts of modified or additional control regulations and initiatives that have not been officially promulgated (as determined by federal, provincial and territorial representatives at the time the forecast was prepared) were not included. The CAC Emissions Outlook provides projections for each of the 10 provinces and three territories (Northwest Territories and Nunavut are projected as one region) for all industrial and non-industrial sources of emissions.

The CAC Emissions Outlook was developed using the 2000 CAC Emissions Inventory, and *Canada's Emissions Outlook*, updated and published in December 1999 by Natural Resources Canada (CEO99). The projections also include sector-specific adjustments based on input from interested stakeholders, industry and government (federal, provincial and territorial) experts, and industry associations. The emissions from the transportation sector were estimated using MOBILE6C for on-road vehicles and NONROAD for off-road engines. These are Canadian versions of the U.S. EPA models[54] for estimating emissions from on- and off-road transportation sources.

This section first presents the trends and projections in the total national emissions for four smog-producing pollutants, followed by the trends and projections in national emissions from major sectors for each of five smog-producing pollutants.

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[54] http://www.epa.gov/otaq/m6.htm (English only); http://www.epa.gov/otaq/nonrdmdl.htm (English only)

6.2.1 National and Regional Emissions

Figure 17 presents the trends and projections in anthropogenic (excluding open sources) emissions of primary $PM_{2.5}$, SO_2, NO_X and VOC for the period 1990 to 2015. The top chart shows this information as national totals, and the two bottom charts as regional totals for western Canada (provinces west of the Manitoba–Ontario border together with the three territories) and eastern Canada (provinces east of the Manitoba–Ontario border).

Between 1990 and 2000, emissions of primary $PM_{2.5}$, SO_2 and VOC all decreased at both the national level (by 21%, 29% and 14% respectively) and the regional level. Emissions of NO_X remained more or less stable at the national level with a slight 5% increase, while at the regional level they increased 24% in the western part of the country and decreased 11% in the eastern part. Emissions of primary $PM_{2.5}$ decreased the most in the western part of the country (26% compared to 17% in the east), SO_2 decreased the most in the eastern part (38% compared to 13% in the west), and VOC reductions were about the same (~20%) in both parts of the country.

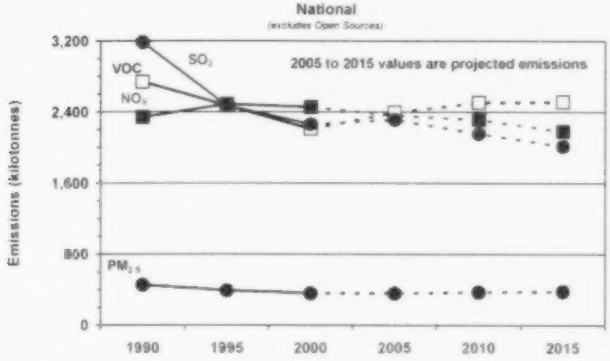
Emissions projections from 2000 out to 2015 indicate that emissions of SO_2 should continue to decrease at the national level, albeit at a slower pace than before, with a decrease of about 11%. Regionally, emissions of SO_2 are projected to increase in the western part (by 16%) and decrease in the eastern part (34%). National NO_X emissions should turn around and begin to decrease with an 11% projected decrease between 2000 and 2015. Regionally, NO_X emissions are projected to remain more or less stable in the western part of the country (4% increase) and decrease in the eastern part (by 30%).

For primary $PM_{2.5}$ and VOC, projections call for a reversal in trends at the national level with a slight increase of 6% for $PM_{2.5}$ and 14% for VOC. Regionally, primary $PM_{2.5}$ is projected also to increase by approximately 6% in both the western and eastern parts of the country, while emissions of VOC are projected to increase significantly in the western part (by 36%) and decrease slightly in the eastern part (by 6%).

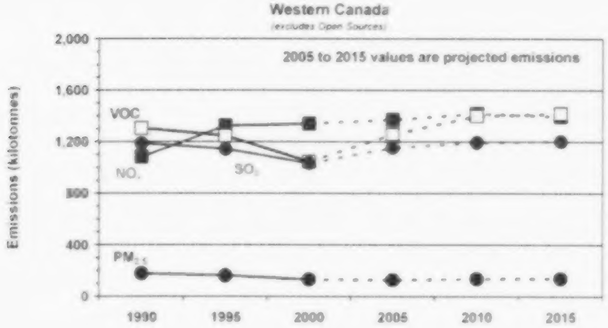
Most of the SO_2 reductions in the eastern part of Canada between 1990 and 2000 were associated with the Eastern Canadian Acid Rain Program. Continued reductions to 2015 are expected to come from the Canada-wide Acid Rain Strategy Post-2000. For NO_X and VOC, most of the reductions came from the transportation sector as a result of federal regulations on vehicles, engines and fuels. These reductions are expected to continue to 2015.

In the west, reductions in NO_X from the transportation sector were partially or fully offset by increases from sectors such as upstream oil and gas (includes oil sands). Projections to 2015 indicate further economic growth in this sector, along with growth in the base metal industry.

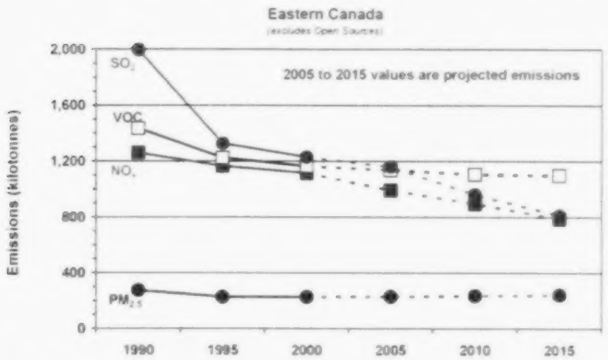
Figure 17: Trends and projections in national and regional anthropogenic emissions of four smog-producing pollutants



	% Change	
	1990 to 2000	2000 to 2015
$PM_{2.5}$	-21	+6
SO_2	-29	-11
NO_x	+5	-11
VOC	-14	+14



	% Change	
	1990 to 2000	2000 to 2015
$PM_{2.5}$	-26	+5
SO_2	-13	+16
NO_x	+24	+4
VOC	-20	+36



	% Change	
	1990 to 2000	2000 to 2015
$PM_{2.5}$	-17	+6
SO_2	-38	-34
NO_x	-11	-30
VOC	-19	-6

Notes: Western Canada includes Yukon, the Northwest Territories, Nunavut, British Columbia, Alberta, Saskatchewan and Manitoba. Eastern Canada includes Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland and Labrador. Data from Environment Canada, July 2006.

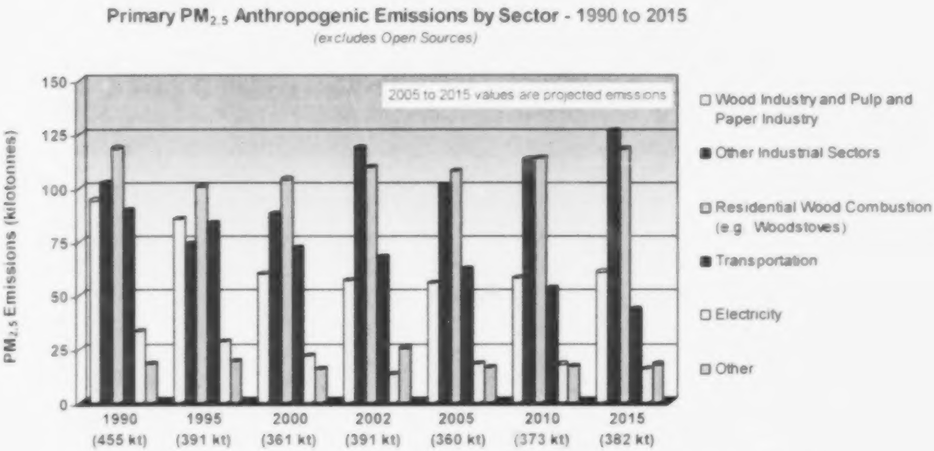
6.2.2 National Sectoral Emissions

This section outlines national emissions trends and projections for major source-sectors for five smog-producing pollutants (primary $PM_{2.5}$, SO_2, NO_X, VOC and NH_3).

Primary Fine Particles ($PM_{2.5}$)

As indicated in Figure 17 above, national anthropogenic emissions of primary $PM_{2.5}$ decreased by about 21% between 1990 and 2000, and are projected to increase slightly by about 6% between 2000 and 2015. Figure 18 below indicates that most of the reductions between 1990 to 2000 came from a general reduction in emissions across all sectors. The slight increase to 2015 is projected to come from both residential wood combustion and other industrial sectors.

Figure 18: Trends and projections in national anthropogenic emissions of primary $PM_{2.5}$ by sector

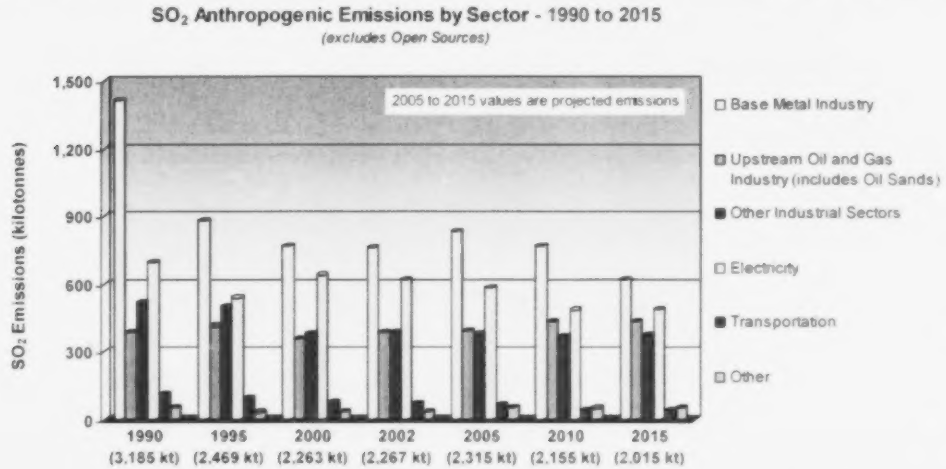


Notes: The numbers in brackets are the corresponding national total emissions for the year. Emissions for 2005 are projections as the 2005 CAC Emissions Inventory is currently being compiled. *Other industrial sectors* include all remaining industrial sectors other than the wood industry and the pulp and paper industry. *Other* includes incineration, miscellaneous, and residential and commercial fuel (excluding wood) combustion.
Source: Environment Canada, July 2006

Sulphur Dioxide (SO_2)

For the period 1990 to 2000, Figure 17 above indicates that national emissions of SO_2 decreased by about 29% between 1990 and 2000, and they are projected to decrease by approximately 11% between 2000 and 2015. Figure 19 below indicates that most of the reductions between 1990 and 2000 came from the base metal industry. The projected 10% decrease between 2000 and 2015 is expected to come primarily from the base metal industry and electricity generation.

Figure 19: Trends and projections in national anthropogenic emissions of SO_2 by sector



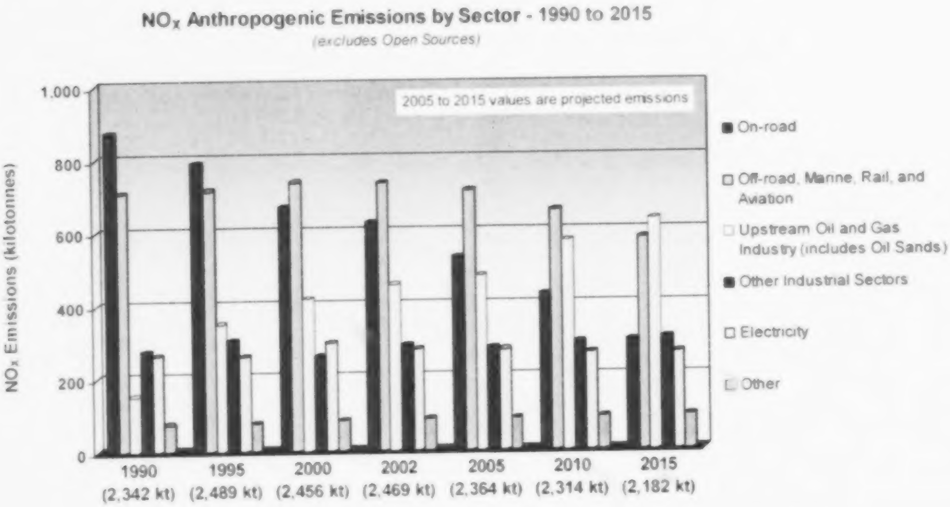
Notes: The numbers in brackets are the corresponding national total emissions for the year. Emissions for 2005 are projections as the 2005 CAC Emissions Inventory is currently being compiled. *Other industrial sectors* include all remaining industrial sectors other than base metal smelting and the upstream oil and gas industry. *Other* includes incineration, miscellaneous, and residential and commercial fuel (including wood) combustion.
Source: Environment Canada, July 2006

Nitrogen Oxides (NO_X)

Figure 17 indicates that national NO_X emissions remained more or less stable, with a slight increase of 5% between 1990 and 2000, and they are projected to decrease by about 11% between 2000 and 2015. Figure 20 below shows that NO_X emissions from the transportation sector (on-road and off-road, marine, rail, and aviation) decreased consistently between 1990 and 2000, while emissions from upstream oil and gas (includes oil sands) increased. Most of the emissions from this latter sector come from the western part of Canada. Projections to 2015 indicate that NO_X emissions from the transportation sector will continue to decrease, while emissions from upstream oil and gas industry will continue to increase at an accelerated pace. Emissions from other source-sectors changed little between 1990 and 2000, and are not expected to change significantly by 2015.

Of note in Figure 20 is the change in the relative importance of emissions between on-road vehicles and off-road vehicles and engines. In 1990, emissions from on-road vehicles were larger, due mainly to the much higher number of on-road vehicles. However, as the decade progressed, emissions from on-road vehicles consistently decreased as cleaner engines and fuels gained greater market share, while emissions from off-road vehicles remained more or less stable, and by 2000 off-road emissions surpassed those from on-road vehicles. Continued reductions from on-road vehicles coupled with slower reductions in emissions from off-road vehicles, should lead to a widening gap between the two sectors by 2015.

Figure 20: Trends and projections in national anthropogenic emissions of NO_X by sector



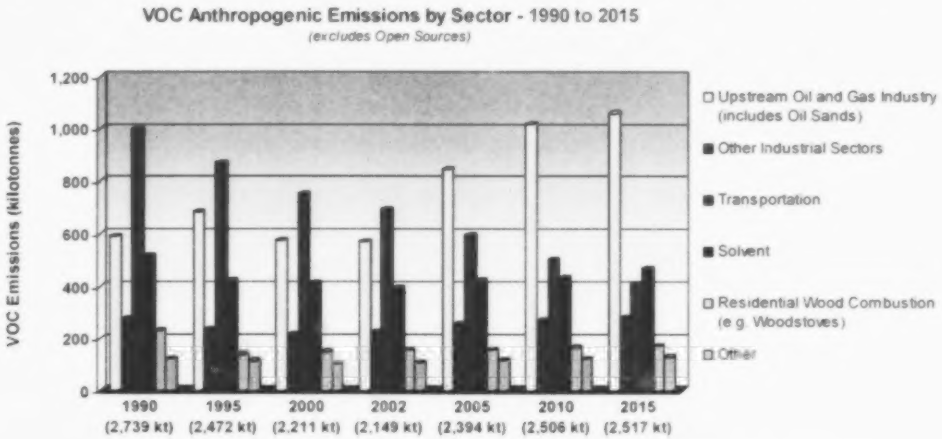
Notes: The numbers in brackets are the corresponding national total emissions for the year. Emissions for 2005 are projections as the 2005 CAC Emissions Inventory is currently being compiled. *Other industrial sectors* include all remaining industrial sectors other than the upstream oil and gas industry. *Other* includes incineration, miscellaneous, and residential & commercial fuel (including wood) combustion.
Source: Environment Canada, July 2006

Volatile Organic Compounds (VOC)

Figure 17 indicates that total national VOC emissions decreased between 1990 and 2000 and are projected to increase slightly between 2000 and 2015. Figure 21 below shows that most of the reductions between 1990 and 2000 came from the transportation sector and solvent use. Emission reductions from the transportation sector are projected to continue out to 2015. Emissions from upstream oil and gas industry (includes oil sands) were more or less stable from 1990 to 2000, but are projected to nearly double out to 2015, offsetting the projected reductions from the transportation sector.

Transportation was the largest contributor to VOC emissions from 1990 to 2000. However, a continued decrease in emissions projected for the transportation sector, coupled with an increase in emissions from upstream oil and gas industry, will see this latter sector become the largest emitter of VOC. Out to 2015, VOC emissions from transportation are also projected to be surpassed by solvent use.

Figure 21: Trends and projections in national anthropogenic emissions of VOC by sector

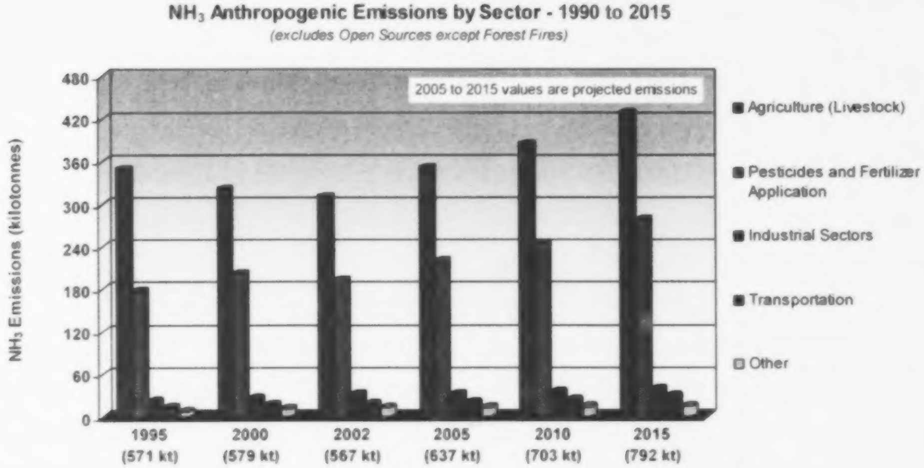


Notes: The numbers in brackets are the corresponding national total emissions for the year. Emissions for 2005 are projections as the 2005 CAC Emissions Inventory is currently being compiled. *Other industrial sectors* include all remaining industrial sectors other than the upstream oil and gas industry. *Other* category includes incineration, miscellaneous, electricity, and residential and commercial fuel (excluding wood) combustion.
Source: Environment Canada, July 2006

Ammonia (NH_3)

Canadian comprehensive ammonia inventories began with the 1995 inventory year. Preliminary projections of ammonia emissions are for continued growth (Figure 22) in livestock and fertilizer applications based on economic growth in the agriculture sector.[55]

Figure 22: Trends and projections in national anthropogenic emissions of NH_3 by sector



Notes: The numbers in brackets are the corresponding national total emissions for the year. Emissions for 2005 are projections as the 2005 CAC Emissions Inventory is currently being compiled. *Other* includes agriculture tilling and wind erosion, incineration, miscellaneous, electricity, and residential and commercial fuel (including wood) combustion. **Source:** Environment Canada, July 2006

6.3 United States Emissions Trends and Projections

For jurisdictions highly impacted by transboundary air pollution from the United States, achieving the CWS will be strongly dependent on reductions in transboundary flows. This section discusses trends in emissions of sulphur dioxide, nitrogen oxides and volatile organic compounds for specific regions of the U.S.

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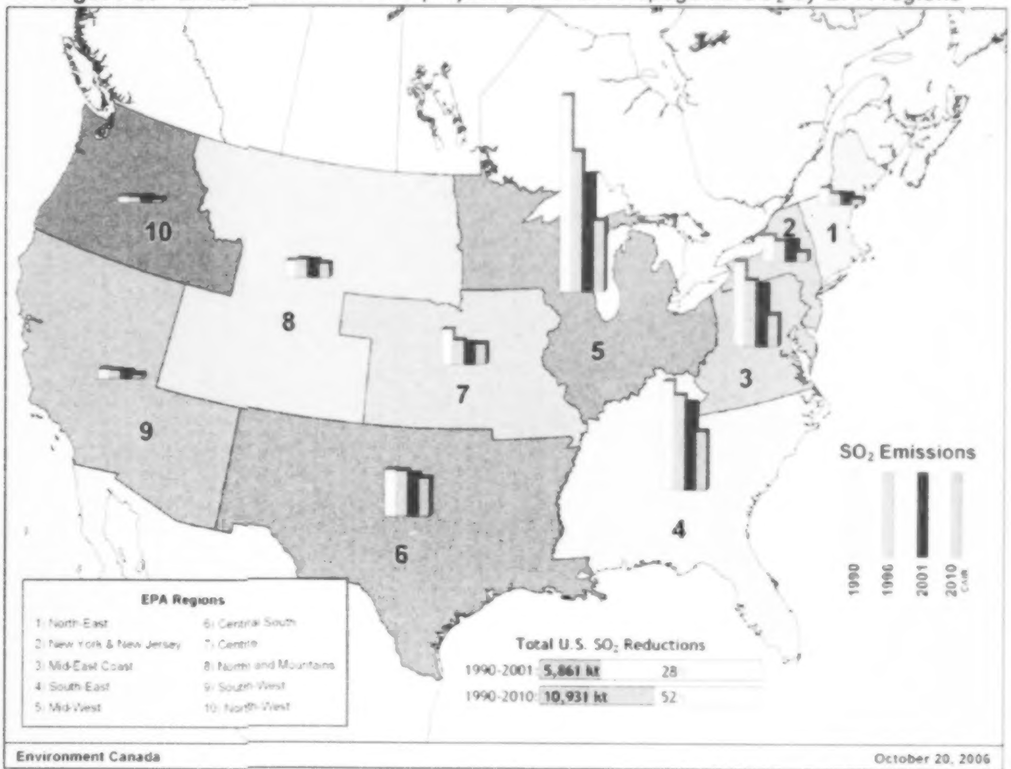
[55] Further work is under way at Environment Canada in collaboration with Agriculture and Agri-Food Canada to better characterize the current and future emissions taking into account beneficial management practices.

Sulphur Dioxide (SO_2)

SO_2 emissions in the United States stem primarily from the combustion of coal for electricity generation from power plants. The coal contains sulphur that, when burned at high temperatures, forms SO_2 and other sulphur oxides. The United States has been successful in meeting its goal of reducing SO_2 emissions from affected sources by 10 million tons (~9 million metric tonnes, Mt) by 2010. In 2005, electric power sources in the United States reduced SO_2 emissions by 5.5 million tons (5.0 Mt), or 35%, compared to 1990 levels.

Figure 23 below shows the distribution of SO_2 emissions for select years between 1990 and 2010 (projected) by EPA region. SO_2 emissions are projected to decrease by 52% nationally by 2010 from 1990 levels. This includes reductions that will result from the U.S. CAIR emission caps (see Section 5.6) for 28 eastern states plus the District of Columbia (DC). By 2015, when CAIR is fully implemented, SO_2 emissions from these states and DC are projected to be 59% below their 1990 levels.

Figure 23: Emissions trends and projections of anthropogenic SO_2 by EPA regions



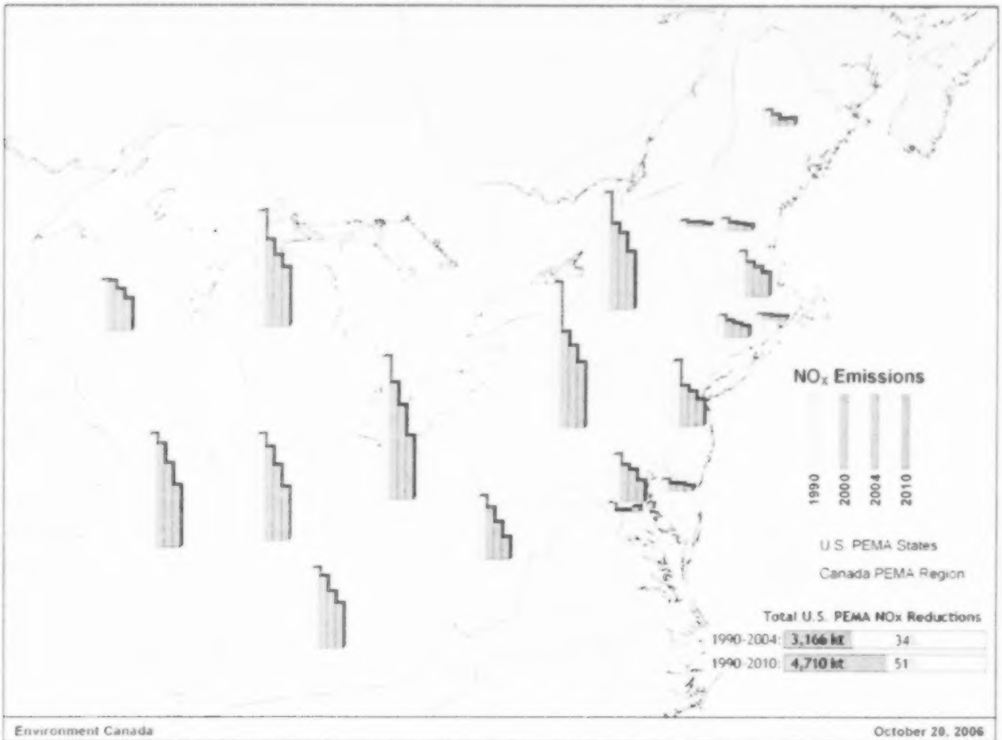
Source: U.S. EPA, September 2004. Emissions shown for EPA regions exclude Alaska and Hawaii.

Nitrogen Oxides (NO_X)

In the U.S. PEMA region, emissions from the transportation sector are the largest contributor to NO_X, accounting for 62% of total emissions in 2004. The electric power sector contributed 23%, industry another 9%, and the remaining 6% came from non-industrial and other sources.

Figure 24 below shows NO_X emission trends for PEMA states in 1990, 2000 and 2004, as well as projected emissions in 2010. For the PEMA states, NO_X emissions decreased by 34% between 1990 and 2004, and are projected to decrease further out to 2010, resulting in an overall decline of 51% from 1990 levels. Major reductions in NO_X are from on-road transportation and electric power generation, including both the ozone season caps required under the NO_X SIP call as well as the annual and seasonal caps for 2009 specified in CAIR (see Section 5.6). When CAIR is fully implemented in 2015, these states are projected to reduce NO_X emissions by 63% from 1990 levels.

Figure 24: Emissions trends and projections of anthropogenic NO_X in PEMA states

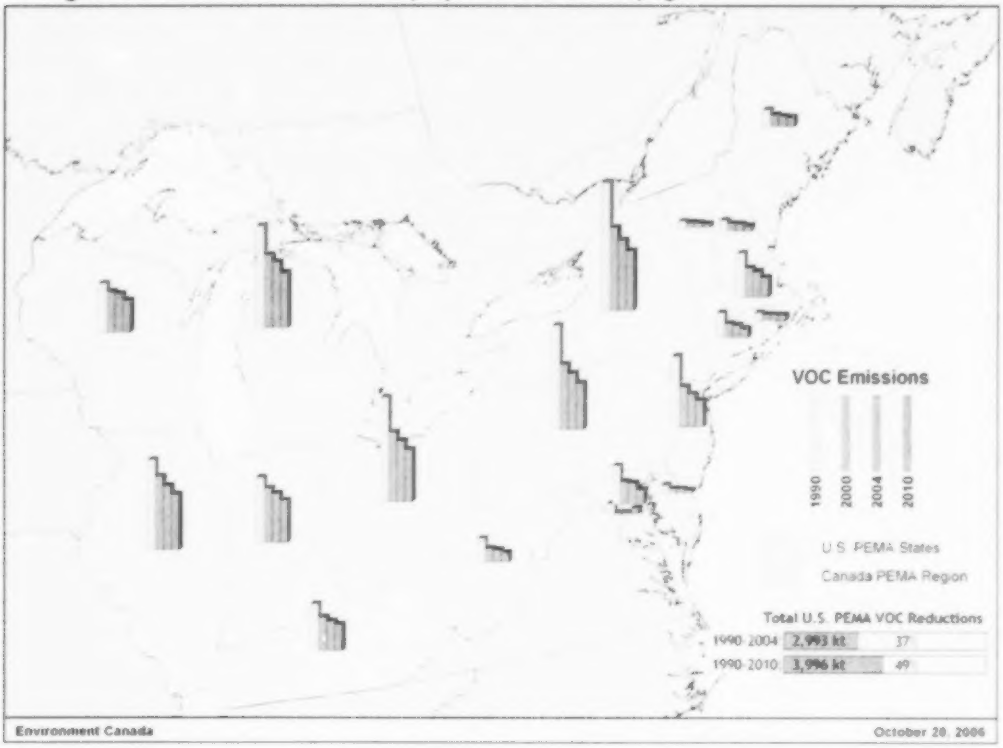


Source: U.S. EPA, October 2002. For 2000 and 2004: U.S. EPA, February 2006. 2010 emissions are projections.

Volatile Organic Compounds (VOC)

VOC emissions in the U.S. PEMA region come from a more diverse number of sectors. Transportation and solvent use accounted for 45% and 27% of total emissions respectively in 2004. Over the 1990 to 2004 period, reductions in VOC emissions came primarily from on-road transportation sources and solvent utilization. Further reductions are projected out to 2010 for the PEMA states, which will result in an overall decrease of 49% by 2010 from 1990 levels (Figure 25).

Figure 25: Emissions trends and projections of anthropogenic VOC in PEMA states



Source: U.S. EPA, October 2002. For 2000 and 2004: U.S. EPA, February 2006. 2010 emissions are projections.

Summary of Section 6

Emissions of SO_2, NO_X, VOC and primary $PM_{2.5}$ have mostly decreased on both a national and regional basis between 1990 and 2000. Although national emissions of SO_2 and NO_x are projected to continue decreasing through 2015, they will do so at a slower pace, while for primary $PM_{2.5}$ and VOC, projections call for a reversal of trends with emissions increasing through 2015. Emissions of ammonia are also projected to increase. Regionally, projections show an increase in emissions of primary $PM_{2.5}$, SO_2, NO_x and VOC in the western part of Canada, and declining emissions for the eastern part, except for a slight increase in emissions of primary $PM_{2.5}$.

Progress has been made by the United States in reducing emissions of NO_X, VOC and SO_2 from transboundary source regions under the Canada–U.S. Air Quality Agreement.

7. DISCUSSION AND CONCLUSIONS

As outlined in this report, progress has been made in a number of areas pursuant to the Interim Plan 2001. These actions have strengthened smog-reduction efforts and made tangible contributions to clearing the air for all Canadians. For example, significant and continuous improvement has been made in reducing emissions from the transportation sector. These regulations will continue to result in reductions in NO_x and VOC emissions, as evidenced by the steady decline in ambient levels of NO_x and VOC across Canada over the past 10 to 15 years.

Similarly, the Government of Canada has made major strides in strengthening emissions reporting, air quality monitoring, and scientific research in support of national air quality efforts. For example, federal investments in monitoring and reporting have led to both greater understanding of key air issues, as well as greater cooperation with other jurisdictions.

Federally led work to reduce transboundary flows of air pollution from the United States has also resulted in clear emission reductions, underscoring the importance of the Canada–U.S. Air Quality Agreement as a key long-term mechanism for progress on transboundary issues.

> ***At least 40%*** of the Canadian population lived in communities with ozone levels above the CWS in 2003 to 2005, and ***at least 30% lived*** in communities with $PM_{2.5}$ levels above the CWS.

Despite improvements in emissions from some sectors and from the United States over the last decade, at least 40% of the Canadian population in 2003 to 2005 lived in communities with ozone levels above the CWS, and these levels have not shown any significant improvement over the past 15 years. During the same period, at least one-third of Canadians lived in communities with $PM_{2.5}$ levels above the CWS. Nearly all of these communities were in Ontario and southern Quebec. Moreover, many other communities across Canada were within 10% of the Standards. The clear evidence of the harmful effects of these pollutants throughout the range of concentrations to which Canadians are exposed leaves no room for complacency. Only further reductions in ambient levels of these pollutants will provide greater reduction in population health risk.

A number of efforts taken to date lay the foundation for further actions to improve air quality in the future. Implementation of actions to reduce VOC emissions from consumer and commercial products, for example, will have a significant impact in reducing VOC emissions from this sector over time. At the same time, further work will be required in both Canada and the U.S. to improve air quality and help all jurisdictions achieve the CWS by 2010. In particular, accelerated efforts are required to determine the sources that are contributing to elevated levels of these pollutants and to implement emission reduction strategies in key sectors. These and other measures will be considered by the Government of Canada as part of evolving efforts toward managing emissions of both smog-producing pollutants and greenhouse gases.

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